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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

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Secretary's Office,
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4th April, 1916. D 974

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LITERATURE.

The British Coal Trade. By H. STANLEY JEVONS, M.A., B.Sc., F.S.S., F.G.S., Professor of Economics at the University of Allahabad. London: Kegan Paul, Trench, Trubner and Co. [Price 6s. net.]

Too much study cannot be given to the many aspects of the coal-mining industry, which has been the main factor in raising Great Britain to the position she occupies, and is yet by no means a spent force. The endowment by Nature has been so generous that we grow unmindful of the extent of the asset so lavishly used and so thriftlessly squandered. The late Professor Stanley Jevons was the first to give due prominence to the need for greater economy in the use of our fuel, and to lay stress on the severe competition we should have to meet from other nations working deposits practically untouched, and at depths easily accessible. He made the nation pause and think of the grim facts that will follow even the partial exhaustion of our coal resources. After the lapse of half a century, it is fitting that his son should invite us to consider the problem more narrowly, particularly in regard to the economic and social aspects which time, the sense of increased responsibility, and experimental legislation have alike forced upon public attention. The facts and deductions of the author refer to the conditions that obtained before the war, and it would be unsafe to forecast the future entirely on such foundations, for a breach of continuity may be anticipated, dividing the earlier history of the social development of the mining industry from the later. The guidance of the future will be best effected by a wide knowledge and capable interpretation of the past; but in any case there is so much that is obscure, owing to the continuance of nearly obsolete methods and customs in the conduct of the trade, that the hand of a master is necessary to unravel the tangled accumulations. This service Professor Jevons renders, and those who follow his picture delineating the life of the miners, their organisations and struggles, will better understand the delays and bickerings, the compromises and negotiations, that at times of crises weary and distress an impatient public.

The earlier chapters on the nature and deposition of coal-seams, with particular reference to the British coal-fields, are necessarily wanting in thoroughness, and make but an inadequate preparation for the close and full discussion of important topics connected with trade unionism, Mining Acts, Conciliation Boards, and other agencies that determine the relations between the miner and the coalowner. An exception may be made in favour of the chapter on the Kent coal-field, which after having passed through some unfavourable financial conditions, is now represented by the author in a very rosy light. The Kent coal-field may be regarded as a triumph of science over deep-rooted prejudice. If the coal-field exists to-day as a hopeful undertaking, it is due to the fact that the confident expert opinion of mere geologists has been able to outweigh the contempt and hesitation of the financier. This coal-field presents a unique instance in this country of the discovery and exploitation of a concealed coal-field, whose position was not indicated by the proximity of exposed and well-known fields. It has won its way to comparative success in spite of ridicule and pecuniary troubles, and it may seem ungrateful not to be able to share the enthusiasm that possesses the author concerning its future. He entertains no doubt of the full realisation of its early promise, and already sees the Kentish landscape transformed by the appearance of mining villages, and a network of railways carrying coals to ports on the South-East Coast, while electric power generated in the coal-field may be transmitted in bulk to London. This glowing picture is built on the somewhat slender basis that from a single colliery before the war the weekly output was 2000 tons. This is a matter for congratulation and hopefulness, but we can hardly follow the author in the assertion that the colliery development has triumphed over all disappointments and difficulties. Sir Joseph Prestwich pointed out that the water in the lower greensand might prove a serious trouble in sinking to great depth, and this prophecy was not only justified, but, now that the boring has been successfully accomplished and workable coal has been reached, the watery strata have proved a very considerable hindrance. The really valuable coal, described as a magnificent seam of "high-quality navigation steam coal" 9 ft. 6 in. thick, is 3318 ft. below the surface, making the pit one of the deepest in the British Isles, whose economical working will have to encounter many drawbacks. Of greater value than the raising of a few thousand tons of coal is the pioneering work accomplished by the Kent subsidiary companies in proving the coal over a considerable area. It seems certain that the coal-field is not less than 150 square miles in extent—the author claims 250 square miles—and at a moderate computation possesses a reserve of 2000 million tons. Professor Jevons insists that the proved reserve is three times this quantity, and gives reasons for thinking it may exceed four times that estimate. Without indulging in the dreams that these large figures awaken, the opportunities are sufficiently great, and are not the less assured, if, as we understand, German capitalists connected with the Westphalian Syndicate are acquiring property and putting up money for further developments.

The chapters on the technology of coal-mining, shaft-sinking, the winning of coal, and the recovery of by-products are written in quite a popular form that will prove abundantly interesting to those who have no occasion to probe the matter very thoroughly. The extent of the ground covered does not permit of detailed information, and some statements without qualification may be misleading, as when we are told that the "recovery and separation of by-products is a new industry which has come over from Germany." The author may, however, be better justified in anticipating such an increase in the demand for by-products from bituminous coal that these may be worth more than the coal in a solid form.

In treating of the economics of the coal trade, Professor Jevons is on his own ground, and his information becomes at once more exact and thorough. The factors of production, the function of management, the sale and transport of coal, the influence of markets, and such questions are adequately and luminously treated. On the subject of amalgamations of colliery management as established in the South Wales district, and of the "kartel" in connection with the Westphalian Syndicate for regulating output and maintaining a remunerative average price-level, the author's remarks are worthy of consideration.

In South Wales the amalgamation movement is extending considerably and, as represented here, beneficially. Many economies in management naturally follow, and the workmen, who are largely in favour of the nationalisation of mines—which, perhaps, means nothing more than that they are dissatisfied with present conditions — welcome schemes that have the appearance of approaching this ideal. The South Wales anthracite field offers a favourable opportunity for putting the experiment to practical test. The field is comparatively small, and requires but a moderate capital for working and for acquiring the necessary proprietary rights. There is little or no competition in this particular class of coal, at least in Europe, and it would be possible to try the experiment of securing a monopoly and of maintaining the price by restricting the output. "As a monopoly is certain to be established sooner or later," says Professor Jevons, "I strongly urge that an experiment in the nationalisation of mines should be made by securing the anthracite coal-field for the nation and working it through a board or trust."

The method of paying wages and the intricacy of mining laws, though simplified by recent codification, are both subjects for the expert. The relics of obsolescent procedure have been so incorporated with modern devices that the system has grown cumbrous in its working, leading to confusion and, consequently, dissatisfaction and strikes. The existence of "abnormal places," that disquieting feature of which we heard so much in the 1912 strike, supplies a source of perpetual friction that the wit of man does not seem capable of removing. The principle of the "sliding scale," that looks so fair but can prove so deceptive, is another fruitful source of discontent, aggravating evils that it was intended to remedy. The miners were quick to detect that the market price of coal is by no means the only indication of the coal-owners' ability to pay wages. The volume of trade was found to be a controlling factor of quite equal potency, and when dissatisfaction was rife the men urged that the sliding-scale operated as an incentive to the coal-owners to sell at a low price whenever trade was depressed, for what was lost in price was made up by the reduction in wages. The workmen's interests would have been better met by working short time, since, by restricting the output, the market price of coal could be kept up, and they could demand the same wages for less working hours. The fluctuations in the weekly wage were very great, dropping rapidly as the price fell, and the uneducated miner, who could not tell how much he was to receive, but knew it was a steadily diminishing quantity, tersely expressed his objections to the automatic mechanism of the sliding-scale by remarking that "the cursed thing had no bottom." It is not easy to see what the variations did amount to, because these are not expressed in shillings and pence, but in percentage of a standard wage at a particular time that was arbitrarily made the basis to which calculations referred. The system is not only cumbrous, but to the uninitiated confusing, and holds the attention with all the fascination of a puzzle.

The difficulty of the problem, bristling as it does with all sorts of surprises and anomalies, does not end here. By way of simplification, a complicated machinery of "Conciliation Boards" has been erected, in order to determine from time to time the percentage at which wages in each district should stand above the base, which is separately fixed for every grade of labour in each seam of every colliery. Add as other disturbing factors the irritating influences of trade unionism, the characteristics and temperament of the Celtic miner, and little wonder need be felt that the tottering structure crumbled under its own weight, and a national coal strike resulted, which had for one of its aims the determination of a minimum wage for underground workers. Through all the elaborate negotiation of that time the author proves a very competent guide, holding the balance impartially between the contestants, and making clear the difficulties that hindered statesmen. If the question were one that less affected the conduct and prosperity of the entire nation, if "coal" and "power" were not synonymous or interchangeable terms, and we could assume a detached position, the history of the 1912 coal strike would possess the excitement and interest of a thrilling romance. In time and consequences the strike is so near to us that it can be viewed only as a grim catastrophe.

The chapters that will probably be read with greatest attention are those on the "Coal Question," a term including such topics as the possible exhaustion of our coal-measures, or their reduction to such an extent that they cannot be profitably worked when faced with severe competition; the development of the coal trade; the employment of oil fuel as a substitute for coal in steam-raising; and the total resources of coal on which the world can rely.

In view of the extent to which abundant coal has established our prosperity, it is not surprising that speculation upon the probable duration of supply has ever been an attractive theme. The surprise should be rather that the unremitting attention of experts has not been brought to bear upon the problem, in order to enforce methods of stringent economy both in mining and in the utilisation of coal for power and industrial heating, since on fuel, and on its cheap and easy acquisition, depends our continuity as an empire and the maintenance of our position in influence and commerce. Our supineness can be traced in some measure to the want of accurate statistics and their intelligent discussion. The optimist may declare that our coal is sufficient to last a thousand years, and the pessimist may prove that we are already suffering from a shortage that will become intolerably acute in another century. Neither can be authoritatively contradicted. One class points exultingly to the discovery of new and unworked coal-fields, the other to the decided rise in the price of coal as evidence of scarcity. According as we select our guide we shall indulge in visions of unbounded prosperity or be led to feel that our anxiety is only too well justified. The author writes temperately, and surveys the various issues dispassionately; but the prophets of approaching disaster are growing in number and influence, and it is impossible not to recognise that with increasing depth, with greater difficulty in working thinner seams, and with the gradual removal of workable coal to more remote distances from the shaft, the cost of mining must be augmented, and sooner or later become prohibitive. The fact which cannot be shirked is, that whatever

may be the amount of coal in our mines, much of the more accessible and more profitably worked has been consumed and cannot be replaced.

Speculation on the rate of expansion of the coal-mining industry, on the demands of the future, and the new requirements that will have to be met, must be even more indecisive than the stock-taking of the reserves. The author discusses some of the factors that will influence development, but the number of those omitted is probably greater. He may entertain the hope that universal peace will reign and that nations will adopt a free-trade policy; but from our present experience it is hard to conceive either that nations will learn war no more or that, having failed to be convinced of the advantages of free trade from the study of our example in the last half century, they will suddenly be converted and adopt our fiscal policy. The possibilities of liquid fuel are still vague and ill-defined, but introduce a great element of uncertainty in calculating future development. At present it would be rash to say that petroleum in its various forms constitutes a serious rival to coal, or that for the production of power in this country it is likely to displace solid fuel. Oil, like coal, is subject to exhaustion, and the evidences of depletion of oil-lands are as convincing as those that point to the disappearance of coal measures. In both cases, the world is disposing of its capital with reckless extravagance, and no means of replenishing the supply have yet been discovered. The one lesson that is to be taken to heart, and the one necessity that has to be faced, is the practice of stern and systematic economy, the urgency of which has long been insisted upon by the few, but is now gaining general acceptance. The wider recognition of the need is the best augury for the successful handling of the problems that together form the "coal question."

BOOKS RECEIVED.

Lockwood's Builders,' Architects', Contractors', and Engineers' Price-Book for 1916. Edited by R. STEPHEN AYLING. London: Crosby Lockwood and Son. [Price 4s.]

The Railway Year-Book for 1916. *The Whitaker of the Railway World.* London: The Railway Publishing Company, Limited, 30, Fetter-lane, E.C. [Price 2s. 6d. net.]

The Public Schools Year-Book, 1916. Edited by H. F. W. DEANE, M.A., F.S.A., and W. A. BULKELEY EVANS, M.A. London: The Year-Book Press. [Price 5s. net.]

London Shipping: A Complete Directory, Personal and Official, to the Shipping and Allied Trades and Institutions in the Port of London. 1916 Edition. London: Offices of the *Journal of Commerce.* [Price 1s.]

THE NEW RHONE-MARSEILLES CANAL.

AMONG the important works which have been in progress in France for a few years past, and which are being proceeded with notwithstanding the war, we may mention the canal now being completed between the port of Marseilles and Arles, on the Rhone, a part of which runs in tunnel under the Nerthe range of hills to the north-west of Marseilles. The work is of technical interest, as will be seen from the following illustrated description; there is reason to believe also that it will prove a commercial success, although expectations in this respect have no doubt been considerably exaggerated, as frequently occurs in the case of artificial waterways. The object in view when designing the canal in question was to connect Marseilles, the premier French port, and one serving numerous industrial establishments, with the centre of France, by a waterway able to deal with a larger amount of goods of greater bulk than can be carried by the existing railway. There being a number of French canals connected to the Rhone and to its tributary, the Saône, the new canal will put Marseilles in direct communication by water with a large part of Northern Europe. The scheme we illustrate on the present page and pages 317, 318, and 326 is being carried out with financial aid from the State, the Department of the Bouches-du-Rhone, and, more especially, from the Chamber of Commerce of Marseilles, which expects great results from the work.

A scheme for such a canal was put forward as early as 1820, at a time, therefore, when there were no railways. This was not given effect to, and a further scheme was proposed in 1840, in which the canal was made to run through the Nerthe range, with a shorter tunnel than that now nearing completion, but with a number of locks to make up for the difference in level. At this latter date, the railway line from Lyons to Marseilles was not yet built, and the promoters of the canal scheme had selected for their tunnel the site which, later on, in 1843, was taken for the railway tunnel. The question of a canal to Marseilles was taken up afresh in 1873, and a scheme was then put forward to build a waterway following the coastline; this scheme was found to require a waterway of too great a developed length, and it was abandoned for another in which the canal ran in tunnel for part of its length, notwithstanding the cost of tunnelling and the extra charge for dealing with the traffic through the tunnel. In the scheme of 1873, the canal started from the north basin of Marseilles harbour, followed the coast in front of L'Estaque, i.e., the point where the railway line emerges from the Nerthe railway tunnel (Fig. 1), continuing along the coast (Figs. 15 and 16, page 326) up to the Lave point, then

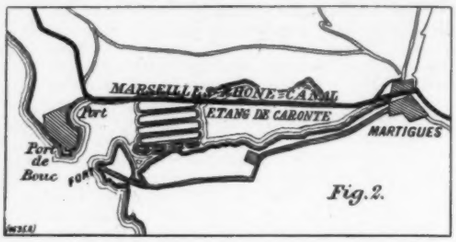


Fig. 2.

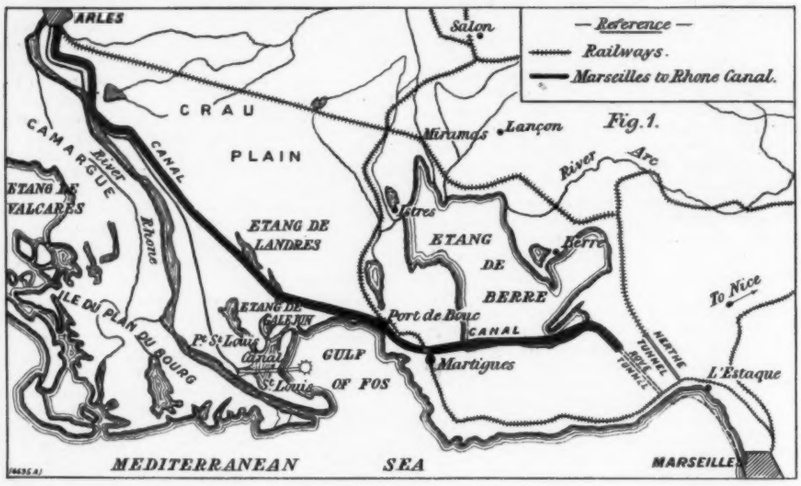


Fig. 1.

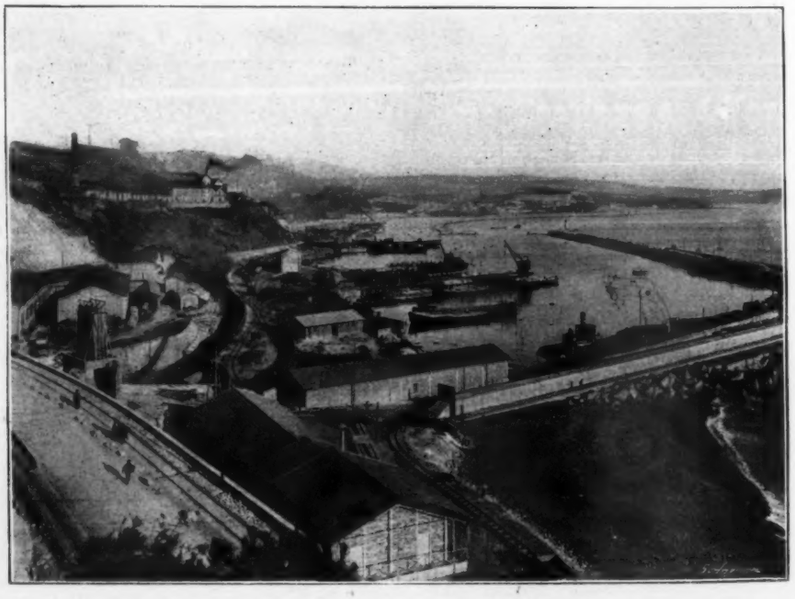


FIG. 3. PORT LA LAVE, WITH CANAL ALONG COAST TOWARDS MARSEILLES.

to enter the tunnel. On leaving the tunnel on the north side it utilised two salt-water lakes, the larger being the Etang de Berre, meeting an existing canal joining Martigues and Port de Bouc, and also an existing canal from this latter place to the Rhone. The cost was estimated to reach 80,000,000 francs (3,200,000*l.*).

The construction of a canal joining Marseilles to the Rhone—the one we now illustrate—was declared a work of public utility by a law passed in the French Parliament on December 22, 1903; it forms part of a vast programme of inland navigation which is far from having been followed up. This canal scheme was very similar to the one put forward thirty years before, except that it was to enter the Rhone at Arles. The engineers who drew up the scheme estimated that its cost would reach 94,500,000 francs (3,780,000*l.*); but Parliament, later on, reduced this amount to 71,000,000 francs (2,840,000*l.*) in order to diminish the total figure for the vast programme referred to. At the present time the outlay, which has been made in the course of construction, reaches a total of close upon 89,000,000 francs (3,560,000*l.*), and the actual cost will certainly exceed this latter figure.

It is interesting at this point of our description to review briefly the conditions under which navi-

gation on the Rhone has been carried on hitherto. Traffic on that river will always be surrounded with difficulties, and will continue to be so, even when direct communication by water is established between Marseilles and Arles. By its direction, its situation, and the volume of water it carries, the Rhone is certainly the most interesting French river. It has been utilised in the past in a large measure, and since 1878, under the influence of the great enthusiasm shown in France in favour of internal navigation schemes, its flow has been improved from time to time. The river in its main direct water line. Utilising other French canals in the vicinity of Paris, direct communication is obtainable by water between Southern France, Belgium, and the Rhine. In regard to volume of water, that of the Rhone is more than sufficient; it would be ample in all seasons to ensure navigation in good conditions were it not for the irregularity of its bed, which prevents the water from spreading uniformly over its whole length and breadth. The Rhone is clearly a torrential river; its bed is not stable, notwithstanding the works of regulation which have been carried out.

Fig. 4.

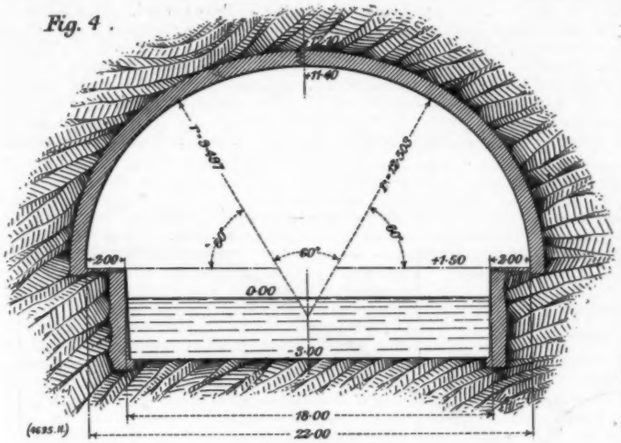


Fig. 5.

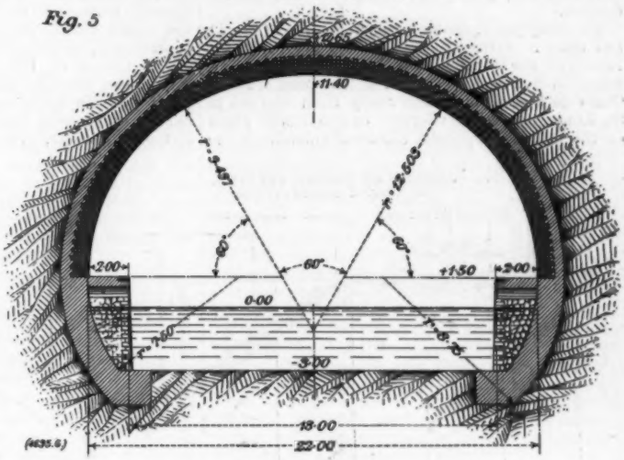


Fig. 6.

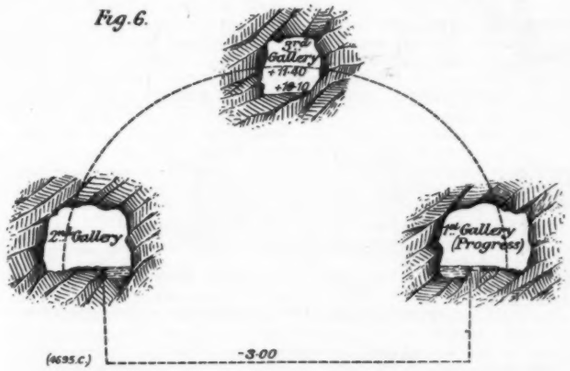


Fig. 7.

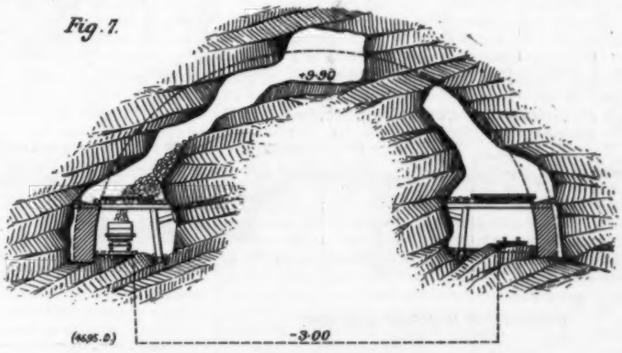


Fig. 8.

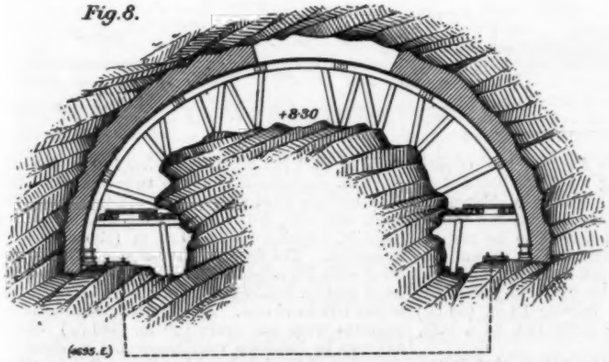
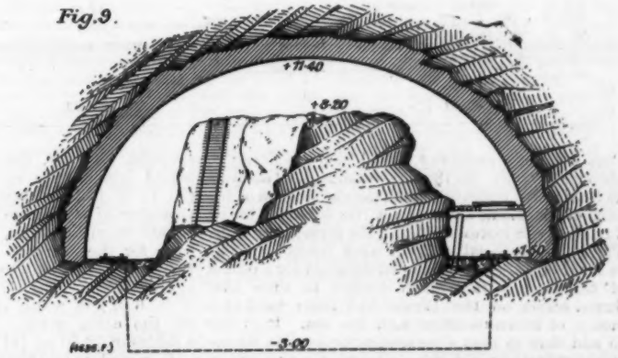


Fig. 9.



portion runs in a north to south direction, and is continued northwards at Lyons, and in an almost straight line, by the Saône, thus forming a water-course which should be capable of placing the Mediterranean in direct communication with Northern Europe. It is even, it might be said, the sole water-course available in this respect, for there are practically no other important water-courses which flow southwards into the Mediterranean. Unfortunately, the flow of the Rhone is ill-suited to modern navigation methods with large craft, and large craft have to be resorted to in order to reduce the cost of transport. Were it not for these circumstances, and were the time question negligible, the Rhone, Saône, Burgundy Canal, Yonne, and Seine would afford a most advantageous Sandbanks are constantly being formed in its course, and the gradual clearing away of the forests on the neighbouring mountain sides in France facilitates their formation to a still greater extent. The bed is constantly being displaced, and, as a French engineer has stated, the Rhone forms two rivers, one liquid and one of small stones, which both roll down together. At many points the down gradient is very heavy; it varies from 40 cm. to 50 cm. per km. (1 in 2500 or 2000) to as much as 2 m. (1 in 500), whilst between Arles and the sea it is only 4 cm. per km. (about 1 in 25,000). Rapids, therefore, are met with, between which there are deep pools, depths and shallows alternating over the whole course. Matters in this respect have been improved somewhat by the regulating work carried out during the last thirty years; formerly the boats had to be built so as to resist the stresses due to the high speed of the currents and had to be on a minimum draught so as to float over the shallows. At one time the question was raised of building a canal parallel with the Rhone, but this it was estimated would cost at least 255,000,000 francs (10,200,000*l.*), and has since been dismissed as an impossible task. The work of regulation has had for effect to give a depth of water of 1.50 m. to 1.60 m. (4 ft. 11 in. to 5 ft. 3 in.) at the shallows, instead of about 0.85 m. (2 ft. 9 in.), which was formerly the depth at these parts. Since that depth was attained the inland navigation companies which utilise the Rhone conduct the service by means of barges 60 m. (197 ft.) in length and 7 m. (23 ft.) in breadth, carrying about 300 tons, and hauled by tugs in the sections of the river where the current is not too strong. At other sections haulage is effected on a towing-chain, the tug running down in the morning on the chain, and running up again before evening, so as to prevent the chain from remaining inactive too long, and becoming embedded in the sand and gravel.

As will be seen, therefore, the Rhone is not comparable to the Rhine from the point of view of traffic. It has, nevertheless, been utilised to a con-

siderable extent, and for many years past strings of barges coming down the Rhone have proceeded from the mouth of the river (Fig. 1) to Marseilles, Toulon, Nice, and Cette. These barges are capable both of navigating the river and being towed at sea. A canal has been in service for the last fifty years or so between Arles and Bouc, which made it possible to evade the irregularities which exist in the mouth of the river. This canal cost 15,000,000 francs (600,000*l.*), or over 300,000 francs per km. (19,200*l.* per mile). It has proved useful both for traffic and for drainage purposes. The new canal absorbs this older one, and is also utilised for draining the district.

For many years past also, a port, St. Louis (Fig. 1), has been in existence close to the mouth of the Rhone for the shipment and transhipment of goods. Access is had to it by a canal which opens into the Golfe de Fos, a much safer route from the sea to St. Louis than that afforded by the lower reach of the Rhone. Opposite the canal entrance is the towns and districts located up the River Rhone. The canal section in the straight will always be five times the immersed section of the present Rhone barges when loaded to their maximum carrying capacity, or 600 tons on a 1.75-m. (5-ft. 9-in.) draught. The width of 25 m. (82 ft.) will allow these barges, which are 8 m. (26 ft. 3 in.) in breadth to pass each other easily.

The locks are to be 16 m. (52 ft. 6 in.) in width at the entrance and 160 m. (525 ft.) in useful length. Since the sill of all the locks is 3 m. (9 ft. 10 in.) below datum, the draught of the barges can be increased. It should be added that these 600-ton barges will frequently be able to travel up the Saône and the Doubs, thus covering a distance of 540 km. (335 miles) without breaking bulk.

The tunnel of the Rove, through which the canal runs, was first designed for a width of 18 m. (59 ft.) at the springing of the arch, and was to have a towing-path 1.50 m. (4 ft. 11 in.) in width, forming a bracket, over the whole length. It was

Before commencing actual work on the Rove Tunnel, a disused quarry close to the south entrance had to be levelled down. Two vertical shafts were also driven down to the tunnel's longitudinal axis to facilitate ventilation and to enable the starting of headings from several points at the same time. Moreover, several railway lines had to be deviated in close proximity to the southern entrance. As will be seen from the map, Fig. 1, besides the main railway line from Arles to Marseilles there is a secondary goods line which follows the coast, runs over the canal tunnel, and joins up to the main line at the point where this latter leaves the Nerthe railway tunnel. This latter line may have an influence upon the canal traffic. One of the vertical shafts above referred to is at a distance of about 1½ miles from the northern entrance to the canal tunnel, and the other at 3.3 miles from the same point. The shafts are 3.5 m (11 ft. 6 in.) in inside diameter, and are lined with a cement covering, 0.25 m. (9.8 in.) in thickness. One shaft

Fig. 10. SECTION OF CIGNAC CUTTING. (Northern Entrance to Tunnel)

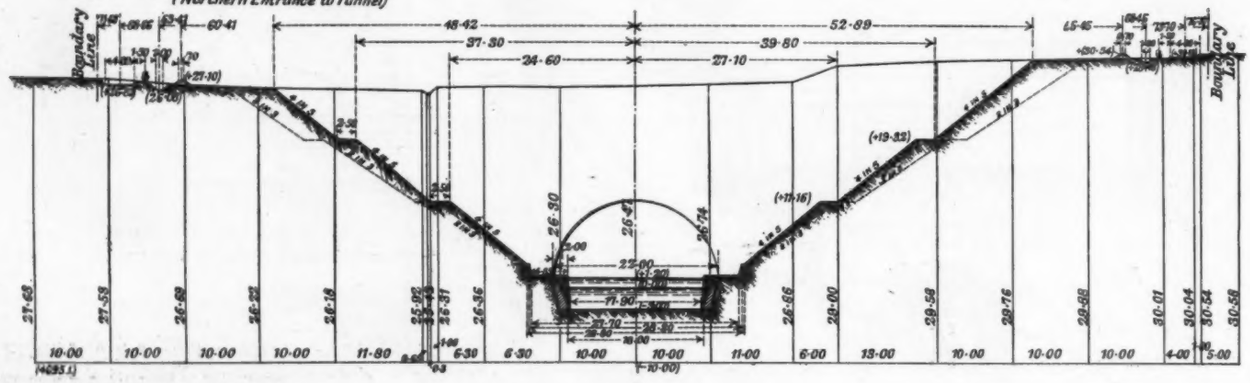


Fig. 11. SECTION OF CIGNAC CUTTING.

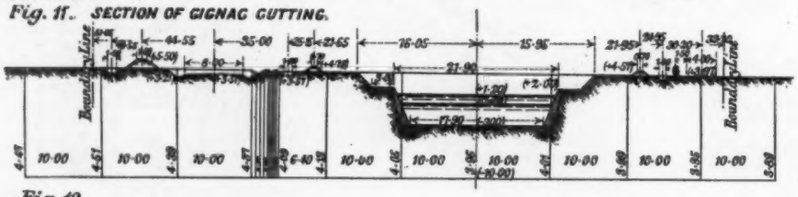


Fig. 12. CROSS SECTION IN L'ETANG DE BOLMON.

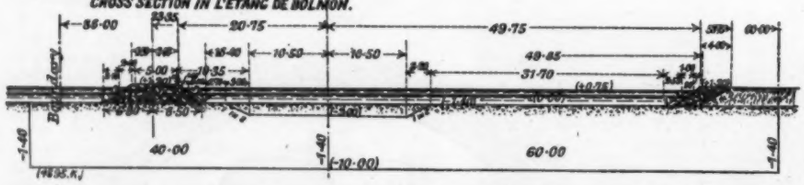


Fig 13

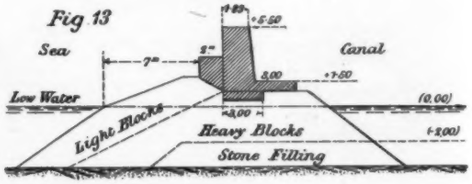
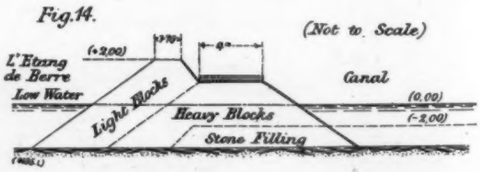


Fig.14. (Not to Scale)



Port de Bouc waterway, called also the Etang de Caronte (Fig. 2). In 1881, the Compagnie Générale de Navigation endeavoured to take advantage of the port of St. Louis and made it the terminus of its fluvial service instead of Arles, the former terminus. The St. Louis Canal and port were ready for traffic in August, 1871, but remained deserted for a period of ten years, a fact which tended to show that fluvial traffic on the Rhone had little need of a means of communication with the sea. It is fair to add that at that time navigation on the Rhone was particularly difficult. Owing to the efforts made by the Compagnie Générale de Navigation, the canal and port of St. Louis have shown some activity since the early 'eighties of last century, but this activity may decrease now owing to the new canal.

The new canal in the sections on a straight line is 25 m. (82 ft.) in width, with a depth of water of 2 m. (6 ft. 6 in.); the normal depth is 2.50 m. (8 ft. 2 in.). The depth is 3 m. (9 ft. 10 in.) between Marseilles and the Etang de Berre, as it is hoped that in that portion of the canal larger craft, sea-going barges, will be used owing to the prospective development of a number of industrial establishments on the Etang de Berre. This presupposes the transhipment of some of the goods loaded on these larger barges and destined for thought, however, that this form of towing-path would hinder the crossing of two boats 8 m. (26 ft. 3 in.) in breadth, and the Marseilles Chamber of Commerce requested that the tunnel should be made wider, and agreed to be responsible for the increase in cost. The tunnel has therefore been given a total span of 22 m. (72 ft. 2 in.) (Figs. 4 and 5, page 317), with two side paths 2 m. (6 ft. 6 in.) in width each, leaving 18 m. (59 ft.) for the canal width. The soffit has, as a rule, a radius of 12.50 m. (41 ft.).

In regard to the work, we may state that in the Marseilles gulf there has been for a considerable time, at a place called La Lave (Fig. 3), a kind of small port used mainly for shipping the stone quarried in the vicinity. The sea entrance to the canal opens out at this place, as seen in Fig. 16, page 326. Between the small port of La Lave and the port of Marseilles proper a dyke is laid down, forming a protected waterway (Figs. 3, 13, and 15). The dyke consists of loose stones; a masonry wall may be built at the site later on. A similar dyke (Fig. 14) is laid in the Etang de Berre. The total volume of stone laid for these dykes amounts to about 420,000 cub. m. (14,800,000 cub. ft.), at a cost of about 5 francs per cub. m. (about 1½d. per cub. ft.), the cubic metre weighing about 2700 kg. (176 lb. per cub. ft.).

is 70 m. (230 ft.) deep, the other 140 m. (460 ft.). For the construction of the tunnel a right-hand side bottom heading was first driven, then a left-hand side one, followed by a top heading (Fig. 6, page 317), each from 7 to 9 sq. m. (about 90 sq. ft.) in section. The floors of the bottom headings were level with the intended towing-paths. The right-hand bottom heading was always driven in advance of the left-hand one. As soon as possible, lateral galleries were cut every 100 m. (330 ft.) between the two to facilitate ventilation and to check the direction of the left-hand heading. Before cutting the top heading, and in order to facilitate the removal of the débris from it, inclined shoot-holes (Fig. 7) were cut every 18 m. (60 ft.) from the top of the two side headings up to the site which was to form the floor of the top heading. This latter heading had a section of about 4 sq. m. (45 sq. ft.). Work proceeded by removing the stone and débris from the centre of the full tunnel section between the three headings and the inclined shoot-holes. The masonry work of the full tunnel proceeded gradually, as shown in our illustrations, Figs. 8 and 9, page 317. No special difficulty was experienced in cutting the invert, or bed of the canal, nor in the masonry work to form the canal sides and towing-paths. The underground water was allowed to flow out by catch-drains, and

pumps were mounted at different points where the gradient was insufficient to allow a natural flow. The springs encountered in course of the excavation were in no way important.

Before the first vertical shaft was reached, ventilation was ensured in the right-hand heading by a pipe 0.550 m. (21 in.) in diameter, communicating at the outer end with a fan driven by a 40-horse-power engine. When the vertical shaft was reached, a fan having a capacity of 13 cub. m. (460 cub. ft.) of free air per second was set working at the top opening of the shaft. Ventilation was further ensured by the compressed air used for the drills and for haulage purposes by 200-horse-power locomotives taking compressed air at a pressure of 100 kg. per sq. cm. (1420 lb. per sq. in.). Lighting of the work in progress was effected by portable acetylene lamps and by a few incandescent electric lamps. An air-compression plant outside supplied the compressed air at 100 kg. per sq. cm. for the locomotives, and at 10 kg. per sq. cm. (142 lb. per sq. in.) for the drills. Close to this was established an infirmary and baths for the men, with dry lockers for their clothes. The air-compression and mechanical plants were supplied from the Marseilles Electric Company, by a line 8 km. (5 miles) in length, with three-phase current at 5000 volts, 50 periods.

At the parts of the tunnel length where the thrust is comparatively low the masonry lining is 0.70 m. (27 in.) thick, and rests at the springing on the natural formation, as shown in Fig. 4. The bed of the canal is lined on the sides with masonry 0.60 m. (23 in.) in thickness. Where the thrust is greater the masonry lining is 1.25 m. (4 ft.) in thickness, and is built as shown in Fig. 5, while the towing-path is built over masonry piers, placed about 2.40 m. (7 ft. to 8 ft.) apart. The stone for the masonry lining was taken from neighbouring quarries; a part of the stone excavated was also used. The necessary sand was obtained by crushing the calcareous stone, this was mixed with "maritime lime," a lime having the qualities of cement, in the proportion of 350 kgr. (770 lb.) per cub. m. (35 cub. ft.) of sand.

As far as can now be ascertained, the work of excavation to the full tunnel section not being yet completed, the total price per metre-run of tunnel of the more simple section, as shown in Fig. 4, is 4227 francs (52*l.* per foot-run), of which 1295 francs (16*l.* per foot-run) is the cost of the masonry work, the remainder being the cost of driving and excavation.

The Gignac cutting is at the north entrance to the tunnel; it is about 2 km. (1.25 miles) in length, and its greatest depth about 30 m. (98 ft.). It involves the removal of about 1,200,000 cub. m. (42,000,000 cub. ft.) of earth, the greater part of which is being thrown in the Bolmon Lake, a small lake which gives into the Etang de Berre, to form sites for the construction at a later date of docks, a great development of industrial establishments in the neighbourhood of the Etang de Berre being anticipated, as stated above. The cutting (Figs. 10 to 12, page 318) was carried out by a bucket-dredger and two 70-ton Bucyrus machines. The cutting is generally 18 m. (59 ft.) in width. The sides rise 4 m. (13 ft.) in height for a base of 5 m. (16 ft.), and are made with benches 2.5 m. (18 ft.) in width. Should the sides not stand, they could be given a slope of 2 in 3. Three bridges are to be built over the cutting, one being destined to carry the track of the small line which runs from Martigues to Pas des Lanciers, and joins the main line from Arles to Marseilles. Two of the bridges are to be built of concrete, the third being a steel structure.

Work generally is being proceeded with less actively at the present time owing to the war, and it is difficult to state at what date the canal will be open for traffic. It is difficult also to form an opinion as to what the extent of the traffic will be. Some engineers have estimated that it will reach 1,400,000 tons per annum. Recent calculations place the maximum traffic at 600,000 tons; half of this latter tonnage is the present traffic by seagoing barges between Marseilles and St. Louis du Rhone, and thence up the Rhone to Arles, which it is expected will take the new canal route; but the Rhone Navigation Companies say, on the other hand, that they will use the canal in exceptional cases only, since the sea passage between St. Louis and Marseilles of their towed barges is but rarely interrupted by bad weather; they also add that this passage is more simple than navigation on a canal and is much less costly. The most enthusiastic advocates of the canal now simply state that the route from Arles to Marseilles by the new canal will be shorter than the present route, part of which is by sea from St. Louis to Marseilles. Engineer experts find the work interesting in itself, but doubt whether any real advantage will accrue, whilst the cost of construction, 89,000,000 francs (3,560,000*l.*), will most probably be greatly exceeded. It is true, on the other hand, that the development of industrial establishments on the Etang de Berre is forecasted, but the hopes entertained in this respect may not be realised. Further, the construction of the new canal coincides with the opening of a new railway line from Miramas to l'Estaque, to relieve the main line from Paris to Lyons and Marseilles, which new railway is destined to serve a part of the new industrial establishments which may be laid down on the Etang de Berre. Moreover, work which is being carried out at Marseilles will cause a number of industrial establishments to be put down at that port. It is to be hoped, nevertheless, that the pessimistic views which are entertained in some quarters in France as to the future of the new canal will not prove true, and that the great enterprise of the Marseilles Chamber of Commerce will meet with the success it deserves.

THE INSTITUTE OF METALS.

(*Concluded from page* 309.)

The Electrolytic Method of Preventing Corrosion.

The first paper taken at the evening meeting on Wednesday, March 29, was the one having the above title, which we reproduced on page 313 *ante*. The author, Mr. Elliott Cumberland, exhibited at the meeting a model of his device, consisting of a small drum having the two ends formed of glass, electrically lighted, and having anodes supplied with current. He stated that the object of his contribution was to describe a system which had proved successful in arresting and preventing corrosion of metallic structures immersed in water or other corrosive liquids. In it he had mentioned various conditions of metals which gave rise to distinctive differences of electric potential, and showed how these were neutralised and overcome by introducing a permanently higher counter electromotive force. He pointed out the uselessness of relying upon auxiliary slabs of more electro-positive metal for permanent protection, and gave a few extracts from a paper read by Mr. J. H. S. Wilson, chief engineer of the Celtic, before the Institute of Marine Engineers, on March 7. Mr. Wilson stated that some two years ago he was having much trouble with the corrosion of condenser-tubes of his ship, many tubes being lost on each voyage. He thought the trouble might perhaps be due to stray currents from the lighting dynamos, and he had the tube-plates, condenser-shell, and the hull of the ship all bonded together with stout copper cable to effectually prevent any stray currents passing from the tubes to the water. An air-valve had already been installed to disperse any existing air or gases, but the trouble continued. He then attached numerous zinc plates to the tube-plates and condenser-doors. On removing some of the zinc plates after they had been in the condenser some weeks, he found them covered with the usual coating of oxidised matter, and on testing with a galvanometer in contact with brass immersed in hot salt water, he found they had reversed their polarity and were reading electro-negative instead of electro-positive. This was a conclusive proof that zinc was not a permanent friend unless some means could be devised by which each plate could always be kept clean and bright while in use; this was, of course, impossible. At this stage the captain adopted the Cumberland method, which had totally removed all the troubles, no signs of corrosion taking place. There had been, further, no leaky tubes in the condensers, and this he wholly attributed to the regular working of the process. Mr. Cumberland then explained this with the aid of the model above referred to.

After a few remarks by Mr. W. E. Gibbs, who stated that the paper was most interesting, but one, he thought, which would gain in value were the actual conditions detailed also on scientific lines, Mr. A. Philip said that he had recommended the process to several of his friends, and it had invariably given absolute satisfaction. In one case, where danger was feared from an accidental reversal of the polarity of the generator, a friend of his had inserted in the circuit a small polarised relay. The power required by the Cumberland process was exceedingly small, he did not think it exceeded one penny per day, and he might say it saved thousands a year by doing away with the necessity of retubing. He congratulated the author for having put forward a most interesting and successful device.

Mr. Rolfe, who followed, said he would very much like to see comparative results given by two condensers, one provided with the author's protective system, and the other without this. With reference to other methods of preventing corrosion, it had been stated that protective rods were of no use, for in course of time they themselves corroded, and, in concluding, he emphasised the point that thoroughly comparative figures should be given.

Dr. Rosenhain expressed the opinion that the theoretical aspect of the author's method had been made quite clear. But he would like to refer to one point more especially which had struck him in the course of the demonstration with the model exhibited. It was well known that when steel bars were pickled in an acid, hydrogen was evolved and the mechanical properties of the steel were influenced thereby. The author's method led to evolution of hydrogen, and he asked whether this, by acting upon the surface of the steel plates forming the boiler, was going to act upon their mechanical properties. He (the speaker) thought this might not be the case, but still there was a possibility of such an action taking place, and he thought the point should be cleared up. Danger under this head was probably very remote, and the author's system no doubt promised to remove the corrosion difficulty in a satisfactory way.

The Chairman was glad that Dr. Rosenhain had called attention to the effect which the solution of hydrogen might have upon the steel forming the boiler. On seeing the experiment made by the author with his model, the same point had appealed to him (the Chairman), and he thought that hydrogen might possibly be a source of a real danger. The point should be kept in mind when dealing with the question of stresses.

Mr. Cumberland, in the course of his reply to the discussion, and with reference to the danger of hydrogen, mentioned trials which had been carried out at a Melbourne power-station, the report of which trials, recently issued, gave, he thought, conclusive evidence that no danger was to be feared under that head. He would deal more fully with the point in a written reply to the discussion. He could give satisfactory scientific data to further explain his process were these needed. It was possible to vary at will the amount of current sent through. And in regard to comparative tests, one had been carried out in Australia; a condenser there had been losing tubes at the rate of a hundred a month, when he (the author) installed his process on one condenser at the plant in question. This was five years ago, and the result was so satisfactory that after a 30-days' trial the whole of the condensers were fitted with the protective device, and instead of losing tubes at the former rate of a hundred a month, the loss amounted to only six tubes in five years. The White Star Line had adopted the device for the last four years and had fitted it on their ships, since when there had been no tube losses.

On the motion of the Chairman, the author was awarded a hearty vote of thanks for his contribution to the Institute's proceedings.

Notes on the Analysis of Aluminium and its Alloys.

The next paper taken was the one on "The Analysis of Aluminium and its Alloys." It was read in abstract by the author, Mr. W. H. Withey, B.A., of the National Physical Laboratory. It dealt with the work on the alloys of aluminium carried out in the Metallurgical Department of the Laboratory, the author confining himself to giving an account of methods which had proved rapid and reliable in continued practice. He emphasised the point that the more useful methods avoided as far as possible the separation of the aluminium, owing to the bulky precipitates which this metal gave and the difficulty encountered in freeing it from the other metals which were so frequently added in the various alloys. These methods possessed, moreover, the advantage that large quantities of the alloy might be used, with the result that

various metals which were added in small amounts only might be determined with the maximum degree of accuracy. The author then described the various processes followed and treatments used in the analyses, and gave the results obtained. He also stated that in some instances a special search was made for vanadium and titanium by colorimetric methods, but without result. Also that in some of the treatments beryllium and zirconia were looked for, but also without result.

After a few complimentary remarks by Mr. Rolfe on the excellence of the work carried out by the author, and a recommendation of the electrolytic method for the separation of manganese, Dr. R. Seligman said it was obvious that the paper was an extremely important contribution to the subject; it formed, in fact, a standard which would prove of very great value. The "omnibus" method referred to by the author would prove specially useful when dealing with unknown alloys. That he (the author) had failed to find the rare metals he mentioned was, perhaps, not very wonderful after all, for he (the speaker) did not think many of the alloys contained them in the first instance. Dr. Seligman, as an illustration of this point, referred to a case, within his knowledge, in which the men in charge of the manufacture of an alloy which was to contain tungsten, dropped the tungsten into the furnace instead of into the pot, owing to the difficulty met with in dissolving tungsten in aluminium; this no doubt applied to many alloys sold as containing such and such more precious metals. The author had shown that all his analyses of samples of aluminium contained small percentages of copper; this was quite a reasonable occurrence to expect.

Professor Turner stated that the volumetric estimation of alloys was a very simple one, it saved a great deal of trouble, and he thought it might be included in the investigation.

Dr. Rosenhain, who closed the discussion, said the paper was a very valuable one. It was, in a sense, a by-product of a series of researches which were being carried out at the Metallurgical Department of the National Physical Laboratory on behalf of the Advisory Committee for Aeronautics and the Alloys Research Committee of the Institution of Mechanical Engineers. That latter Institution had not stifled the work being done; the Laboratory was launching out in other directions, and one of the results was the paper which had just been read to the meeting. He (the speaker) could confirm Dr. Seligman in the latter's remarks as to the rare metals. The author had analysed practically all the aluminium alloys on the market; he had analysed also alloys made up in the Laboratory, and when these were made to include rare metals they were duly found in the analyses. Dr. Rosenhain laid special stress upon the fact that the author's results of analyses gave the percentages of both silicon and silica. The colour of the silica, he remarked, was quite different in different cases, sometimes being very light and sometimes dark. Silicon in aluminium formed a compound, and he (the speaker) anticipated that it would be there as compounds of silicon and silica. The sources from which the aluminium was obtained seemed to affect the results, and it might influence the condition in which the silica and the silicon were found. A method was wanted for the determination of carbon and oxygen in aluminium, since the method used for steel was not suitable, and other methods gave hopelessly variable results, and he commended the problem to all scientists who were concerned with aluminium.

In the course of a brief reply, the author stated that in the case of the electrolytic method the platinum suffered, there occurred, in consequence, losses in weight, and difficulty in weighing the constituent. The alloys he had used varied greatly from sample to sample; in one there was, for example, nine times as much of one constituent as in another; the constituents also varied greatly in different portions of the same bar. The only method he knew for the determination of carbon was that by Moissan; there was no other method available. In regard to oxygen, his efforts until now had been unsuccessful, and he believed the question was one impossible to solve.

On the motion of the Chairman, the author was heartily thanked for his paper.

The Annealing of Nickel-Silver (Part I.).

The paper having the above title, by Mr. F. C. Thompson, M. Met., B.Sc., Demonstrator in Metallography in the University of Sheffield, was then taken. It was read in abstract by Professor Brook. It was not discussed, the Chairman intimating that all remarks should be sent in writing for publication in the Journal.

The other papers on the list were taken as read.

The usual votes of thanks to the Chemical Society for the loan of their rooms, and to the Chairman, concluded the proceedings.

IRON AND COAL IN GERMANY.

The price of bar steel continues to rise; whilst in the beginning of March 160 to 165 marks were still accepted, the quotations of the Rhenish-Westphalian works were at the middle of the month raised to 170 to 175 marks, and in some cases even to 180 marks per ton for Thomas material. The demand from the neutral countries is very active, and contracts have already been placed for delivery in the course of the third quarter of the year.

The German Steel Union during February despatched an aggregate of 282,269 tons, against 285,784 tons for the preceding month, and 266,905 tons for February, 1915. There is a decline in railway material of some 16,000 tons as compared with January, but the deliveries of these commodities vary a good deal from month to month, and the falling off in railway material was almost counterbalanced by an increase in shape iron. The deliveries in February of the different products represented 52.44 per cent. of the allotment.

The report of the Union of German Machine-Tool Makers for last year states that a materially increased demand for machine-tools for military purposes set in directly the war broke out, and has been going on ever since at an undiminished rate. Amongst the companies which have done exceedingly well on account of the war, the Harzer Works at Rübeland and Zorge must be mentioned, having been able to raise their dividend from 6 to 25 per cent., to write off 813,214 marks, against 141,283 marks for the previous year, in addition to which 601,000 marks, from a share transaction, have been written off on buildings, and there are other material writings off besides, and 425,000 marks are reserved for war tax, &c.

The Hugo Schneider Company, metal and brass works, Leipsic, pays 20 per cent. for 1915, against 6 per cent. for 1914. On the other hand, the Bochum Mining Company is unable to pay any dividend, which has caused some surprise, as a dividend of 5 or 6 per cent. had been reckoned upon.

In the Ruhr coal-mining district an increased production of coke is required, as the stocks by degrees have been materially reduced, and some shortage is apprehended.

Since mines like Graf Bismarck have taken up the manufacture of coke, the quality of the Ruhr district coke has undergone a material change, which, however, so far has not had any influence upon the prices. Hitherto the Ruhr district coke has been produced from soft coal, but a few mines, amongst them the Graf Bismarck, have commenced to use other kinds of coal—viz., gas and gas-flame coal.

The sale of coal is somewhat influenced by transport difficulties. Even if the shortage of rolling-stock has ceased to be a permanency, it occurs occasionally. The scarcity of the by-products from the coke manufacture continues and becomes particularly manifest in the spring, when the demand for artificial manure sets in. Sulphate of ammonia is not obtainable in sufficient quantities, and the same applies to toluol and solvent naphtha. Of benzol there are sufficient supplies, also for private consumption, but the stocks are by no means excessive. The manufacture of briquettes has been somewhat impeded by lack of some raw material, but the demand has so far been satisfied.

Examiners for the Aeronautical Inspection Department.—We learn that there are still vacancies for examiners in the Aeronautical Inspection Department. The pay, including allowances, is 3*l.* 15s., rising to 4*l.* 5s., with prospects of further advancement. Candidates should preferably be gentlemen with a good theoretical education, practical experience in engineering, and a working knowledge of scientific measuring instruments. Preference will be given to those who are unlikely to be called up for military service, and who are not now usefully employed on war work. Applications should be made to the Chief Inspector, Aeronautical Inspection Department, War Office, 13, Albemarle-street, London, W.

The Junior Institution of Engineers.—It is announced that Mr. R. Rankin's paper on "Speeding-up in an Engineering Factory," down for reading on Monday evening next, has been postponed till April 18. This paper describes the methods by which the output of certain essential commodities was enormously increased, partly by a modification of method, and in part by the stimulus of increased pay. It has long been known that in very many branches of engineering the normal day's output has been far below any figure that is ethically justifiable. For this condition of affairs neither employer nor workman has been free from blame. The latter will often confess that by small modifications in his method his output could be very greatly increased. The probability that the "office" would immediately steal the fruit of his thought, by cutting down his total receipts to the former value, gives him no inducement towards improvement. In one of the cases mentioned in Mr. Rankin's paper the output was raised from 8 or 12 pieces an hour to 90, though this was an outside figure, observed in one special case only.

"ON THE WHIRLING SPEEDS OF LOADED SHAFTS."

To the Editor of Engineering.

Sir,—I have to thank you for forwarding early copies of the letters you have received from Dr. Chree and Professor Jeffcott on the above subject, although I am afraid that the time I have been able to devote thereto is not altogether adequate for the proper consideration of such extensive correspondence.

In his letter Dr. Chree rightly takes exception to my remarks—in Appendix C—regarding his attitude towards Dunkerley's formula. I gave two quotations from Dr. Chree's paper which of themselves are insufficient to demonstrate his opinion. The reason is that, when engaged in writing my article, I did not have a copy of Dr. Chree's paper, beside me, but had to rely upon some extracts from his mathematical appendix, which I had made in the course of a visit or two to a public library. It is now clear from Dr. Chree's letter, and a reference to his paper, that these extracts stopped at too early a period, with the result that I was led to the misinterpretation to which Dr. Chree calls attention. I am glad that he has done so, as I thereby have my own views put right, and can avail myself of the opportunity to express regret at having, through insufficient knowledge, created a wrong impression of his attitude in this matter.

The part of Dr. Chree's paper which I have overlooked—or rather forgotten about, as I must have read it at one time—deals, as is shown in his letter, with the general case of two loads on a shaft. It will be quite clear that I could have saved myself considerable trouble, and obtained fuller results, by using this method in place of that actually given in Case I., Appendix C, which is only a particular case of the general problem treated by Dr. Chree.

It is interesting to note, from the figures given in Dr. Chree's letter, that the discrepancy between Dunkerley's method and the more correct method would seem to increase as the loads approach the supports, leaving a relatively long central length unloaded. Perhaps this would not occur to the same marked extent with three loads, where one was always central.

As Dr. Chree points out, this method could easily be developed to treat even more elaborate arrangements, although it might be expected that the general expression for R would become very unwieldy. Probably it will be found that the values which have now been given afford a sufficient guide as to the accuracy of the Dunkerley method in the most usual practical cases. In fact, it would seem that Dunkerley's formula is fairly reliable in actual cases—that is, of course, assuming it to be properly used. Moreover, with the correct use of the method a small margin of safety is realised; and this is certainly desirable.

In connection with the employment of the Dunkerley formula in practical cases, it might be worth while to point out that the determination of the correct equivalent uniform shaft is frequently rather difficult, and considerable errors may arise in this step. The accuracy of the results obtained depends so completely on the correctness of the assumed uniform diameter that, in reality, only where the shaft does not vary much in diameter over its whole length can the results be considered reliable. Where, for instance, a short length of relatively large diameter occurs near the centre of a span, it is difficult to refrain from giving it undue value; it really has but a slight effect. It will indeed be found, in the great majority of actual designs, that the graphical method must be resorted to; and that Dunkerley's formula should be used for preliminary work only. I feel certain that Dr. Chree's letter will have made the whole question of the accuracy of Dunkerley's rule quite clear, and will completely dissipate any false impression my remarks in Appendix C may have created.

Professor Jeffcott's letter came as an altogether unexpected surprise. I had not anticipated that the mathematical work would have been assailed, for the reason that, to me, it seemed it could only be wrong if it failed to show the result actually arrived at, so readily comprehensible is the idea, and so inevitably does it follow on previous work on this subject.

Professor Jeffcott attacks my assumption that the rotation is about the axis of the bearings, and considers that it is really about the gravitationally deflected position of the shaft axis at the point of load; and a modification of my investigation to suit this condition fails to show any evidence of the result I had obtained. But, after all, this is only a negative result; it may only be the silent protest of the mathematics against unsound arguments.

While admitting the plausibility of the argument in the case of very slowly moving shafts, where the shaft fibres have time to take up the changing bending stresses due to their changing positions, I find it quite impossible to believe that a whipping shaft is rotating about such an entirely imaginary axis as that through the deflected position occupied by the shaft when at rest. Is it not more sensible to assume rotation about a definite axis such as that of the bearing centres, where the constraining forces come into line with the radial forces?

I think Professor Jeffcott's idea is due to a ready appreciation of the fact that the motion is such as to give a more uniform displacement from the deflected position than from the unstrained position. In this connection I think Professor Jeffcott would have been more correct to have considered v in place of m in his mathematical work. It is the variation in the deflection of the shaft that is to be considered; m might quite conceivably be invariable throughout the revolution. Also I do not understand his reference to my having included the potential energy due to gravity, but omitted the corre-

sponding elastic energy. For the conditions I have taken the investigation is quite complete.

Again, Professor Jeffcott's claim is that rotation takes place about the deflected position because of the effect of gravity on the shaft. One recognises the idea he is following from his consideration of transverse vibration. Now it is easy to see that, in the mathematical study of the transverse vibration, one could consider the shaft as vibrating about the unstrained position with gravity always acting, or as vibrating about the deflected position with gravity absent. Either method would suffice to study the motion. In the case of rotation, Professor Jeffcott assumes the rotation as affected by gravity, and also admits gravity into his investigation. By analogy with the vibration problem this hardly seems correct.

But, apart from all other considerations, I might direct Professor Jeffcott's attention to the "common-sense" idea of the theory which I have given, which idea I endeavoured to make clear in my paper. It was there indicated that under the action of the forces that must exist it was impossible that rotation of the shaft could occur with unchanged elastic form. Professor Jeffcott will recognise that this applies to his case also. The deflection of the shaft from its unstrained position must vary in some way throughout the revolution, the period of the change being that of the revolution. Now Dr. Chree has proved that the frequency of natural vibration of a shaft is reduced by rotation, gradually decreasing as the speed increases, until it is zero at the whirling speed. If this theory is correct—and I do not think Professor Jeffcott will question it—there must at some stage be agreement between the period of revolution (and therefore of the period of disturbance of the shaft form) and the natural period of the rotating shaft. That speed of rotation for which agreement takes place is a critical speed.

This idea is so easily comprehended that I cannot suppose Professor Jeffcott has altogether realised what the proof of its incorrectness entails. It necessitates the establishment of the fact that under the conditions of rotation the elastic form remains unchanged (*i.e.*, Professor Jeffcott's v remains unchanged) throughout the revolution; or it requires proof of the failure of Dr. Chree's theory. The negative result that Professor Jeffcott has actually reached cannot be brought forward as a sound proof either of the truth of his assumptions or of the incorrectness of mine. Indeed, I look upon the fact that my investigation has actually established this result, simultaneously with that which had already been known, as justification of any assumptions I may have made.

When it is thus shown that Professor Jeffcott is hardly justified in his assured manner of dealing with this matter, the necessity for his somewhat elaborate explanation of the occurrence actually noted with the 250-kw. turbine becomes less conspicuous. He attributes the whole affair to looseness in the inner ends of the bearings, which would allow the nodes of the vibration to be out as far as the outer bearing faces, and consequently to give rise to a low critical speed due to the increased internodal distance.

In order to test this I have taken the trouble to make a graphical calculation with the correct shaft dimensions, and have found the critical speed for the 52.8 in. length (*i.e.*, over outer faces of bearings) as 2680 revolutions per minute. This is considerably more than the 2500 revolutions per minute estimated by Professor Jeffcott, and, considering this discrepancy along with the extreme improbability of the nodes being at the outer ends of the bearings, it must be seen that Professor Jeffcott's hypothesis is something of a failure.

Looseness in bearings may serve to make the node positions uncertain over a small internal region, but it is difficult to believe in the extreme cases considered by Professor Jeffcott. His Fig. 1, with its short, wide bearings and shaft centre lines, can hardly be admitted as evidence.

At the end of his letter Professor Jeffcott states, in connection with the alternative solution in my Appendix A, that, "if modified in accordance with the amendments indicated above, will, of course, lead to the same amended equation for m." Professor Jeffcott will not find it so very simple, I am afraid.

I trust that I have dealt with all the essential features of these letters. Several minor points may have been neglected, but this reply is already inordinately long.

In the short note from me which you publish in your issue of March 31, the sentence, "It is also suggested that the margin of safety . . . ", should read "It is also suggestive that . . ."

Yours faithfully,

Airdrie, April 3, 1916. WM. KERR.

THE INSULATION OF FURNACES.

TO THE EDITOR OF ENGINEERING.

SIR,—The recent appeals of the Government to all consumers to economise in coal leads me again to call attention to the needless waste of heat in furnaces. On several occasions I have pointed out in these columns that a great saving might be effected by lagging furnaces with a suitable non-conductor, with the additional advantage of cooling the atmosphere of the workshop, and thus increasing the efficiency of the workers. So far as I am aware, no manufacturer has adopted this suggestion on a large scale in this country; in America, however, furnace insulation is becoming common, and is found to possess all the advantages claimed for it. All interested in this question should read a paper by P. A. Bosck, on "The Thermal Insulation of High-Temperature Equipment," published in vol. xxviii. of the Transactions of the American Electrochemical Society, 1915, in which the subject is fully discussed. Is there any metallurgist in this country prepared to make a practical trial, say, on an annealing furnace? I am persuaded that the result of such a trial would be to establish the economic value of furnace insulation, and lead to its general adoption.

CHAS. R. DARLING.

City and Guilds Technical College, Finsbury, E.C.

"THE FAN DYNAMOMETER."

TO THE EDITOR OF ENGINEERING.

SIR,—Referring to the article on page 262, dealing with the paper by Mr. Hodgson on the above subject in your issue of the 17th ult., as I am the inventor and patentee of the fan dynamometer, and as my firm is the sole manufacturer of fan dynamometers in this country under my patent, it may be interesting for me to refer to the matter.

In 1897 I read two papers before the Institution of Mechanical Engineers, entitled "Experiments upon Propeller Ventilating-Fans." The principles are, of course, the same for fan-brakes and ventilating-fans. Those papers, which were fully discussed, were printed in various issues of your journal in 1897. They treat with about thirty different fans at progressive speeds and powers under different conditions. The natural laws are verified and the mutual relations of revolutions and brake horse-power are given. I then stated a formula giving the effect of atmospheric conditions, which was derived from actual experiment, that the horse-power varied as $\frac{1.3304 \times B}{T}$, where B is the barometer height in inches of mercury and T the absolute temperature. The law that the horse-power varied as the cube of the revolutions was also verified.

It is interesting that these results are corroborated by the author's experiments. Also touching on the subject, I would mention my papers entitled "Experiments on the Arrangement of the Surface of a Screw-Propeller," Institution of Mechanical Engineers, 1892; "Experiments with Ventilating-Fans," British Association, 1893. Three reports to the Royal Society, entitled "Resistance of Surfaces in Air, 1900, 1901, and 1902."

The author of the paper apparently assumes the fundamental law of the fifth power. He endeavours by analysis to divide the resistance into two parts, and gets the resistance of the blades and then the resistance of the arms, the sum of which is shown by the symbol μ. I find, however, from experiment that when the arms are run in conjunction with the blades it affects the sum of the two constituent results to a considerable extent. This is evidently due to the effect on the stream-lines and feed of air into the fan. In other words, I have found that the theoretical law of the fifth power does not follow, but the power is between the fourth and fifth.

I find it much more reliable to calibrate the fan dynamometer on powers about or nearly the same as may be used in practice. For instance, our 150-horse-power type fan-brake, as manufactured by my firm, was tested on four different electric motors, ranging from 5 to 150 horse-power. The results are reduced to a standard barometer pressure of 30 in. of mercury and 60 deg. Fahr., and the correction can easily be made for variation from the standard by the usual formulæ.

Yours very truly,

W. G. WALKER, A.M. Inst. C.E., M.I. Mech. E.

Emery Hill-street, Westminster, S.W., April 3, 1916.

"TURBO-BLOWERS AND COMPRESSORS."

TO THE EDITOR OF ENGINEERING.

SIR,—I beg to draw your attention to an error in the formula given in Messrs. Guy and Jones's paper on "Turbo-Blowers and Compressors," published on page 144 of your issue of February 11, for the work done in adiabatic compression in brake horse-power:—

$$= 2115 \left\{ \left(\frac{p_f}{p_0} \right)^{0.291} - 1 \right\} \frac{T_0 + 461}{493} \text{ B.H.P.}$$

The quantity p_f should obviously be P_f, and the quantity p_0 should be P_0.

Also, in the definition of symbols, since Pb is the barometric pressure and p_0 is the gauge pressure at the compressor suction, the absolute pressure P_0 at the compressor suction should be the sum of these two quantities, and not the difference as stated in the definition.

Yours faithfully,

S. F. BARCLAY, Ph.D., B.Sc.

River Don Works, Sheffield, April 1, 1916.

"ELECTRICAL POWER PLANTS IN THE THAMES."

TO THE EDITOR OF ENGINEERING.

SIR,—The letters of Mr. Anderson and Mr. Nicol commenting on my suggestion that a good way to cure the ills of electrical power generation in London might be to build narrow, long stations in the Thames have been read by me with interest. Mr. Anderson thinks that the only object of this location would be to obtain abundant condensing water. This may be true, but I did not think so when I wrote the letter. There may be many places about London where there is ample condensing water. I do not know whether this is so, but other advantages of the Thames location are that it is central (an advantage seldom secured), an unoccupied location is obtained, it gives an opportunity to start *de novo*, and, as I supposed, furnishes a good solution of the coal and ash problems.

Mr. Nicol's objection to the project is that the coke from gas works could not be utilised conveniently. I frankly admit that I know little or nothing about the fuel supply of London, but apparently other people have ignored the coke supply. As far as my own observation goes I have never seen anybody who wanted to use coke, have never heard of a stoker that burns it successfully, and believe that its peak-load properties are a minimum, and renders it unfit for a service in which small nominal boiler capacity is necessary, and the greatest practicable forcing capacity indispensable.

I have heard and read so much about the smoke of London (my visits have always been in summer) that I should think that coke would be in great demand for house use.

If Mr. Anderson will look at my first letter, he will see that I did not suggest laying pipes on the bottom of the river.

Yours truly,

F. W. DEAN.

53, State-street, Boston, Mass., March 23, 1916.

SUCCESSFUL ENGINEERS.—We read in the *New Age* an interesting paragraph to the effect that there are six groups of factors which are essential to the successful engineer, according to a preliminary investigation made by the Carnegie Foundation for the Advancement of Trading, New York City, as follows:—1. Character, covering integrity, responsibility, resourcefulness, and initiative. 2. Judgment, covering common-sense, scientific attitude, and perspective. 3. Efficiency, covering thoroughness, accuracy, and industry. 4. Understanding of men, including executive ability. 5. Knowledge of the fundamentals of engineering science; and 6. Technique and practice of business. Engineers are being approached on the subject with the request that they will number the six groups in the order of the importance which they attach to them. We wonder whether the above order is the one which the Carnegie Foundation has selected; it seems a most recommendable classification, but is a classification which many Continental educational authorities would not adopt, since they place theory first and last, and allow no time for any other acquirement.

AMERICAN LOCOMOTIVE BUILDING.—Orders for 270 locomotives have been recently received, without counting orders for 350 small 7-ton gasoline engines which the Baldwin Locomotive Works are to build for the Russian Government. The Baltimore and Ohio Railroad Company has ordered 50 "Mikado" locomotives from the Baldwin Works, and 10 "Mogul" engines from the Lima Locomotive Corporation. The American Locomotive Company has also to build 50 "Pacific" engines for the New York, New Haven, and Hartford Railroad Company. The New York Central and Hudson River Railroad Company is building 20 switching locomotives in its own shops for the Cleveland, Cincinnati, Chicago, and St. Louis Railroad Company. The Chicago and North-Western Railroad Company has ordered 35 "Mikado" locomotives, 14 "Pacific," and 28 switching locomotives, or 77 engines altogether, from the American Locomotive Company. The same company is to build 18 engines for the Central of Brazil Railway, and 12 engines for the Chicago, St Paul, Minneapolis, and Omaha Railway Company. Important orders for railroad cars are also in course of execution by American firms.

ROYAL INSTITUTION.—The day lectures after Easter will be as follow:—Mr. Laurence Binyon, two lectures: 1. "Indian and Persian Painting;" 2. "Chinese Painting." Professor Charles S. Sherrington, two lectures: "Harvey and Pavloff." Mr. Thomas Martin Lowry, two lectures: "Optical Research and Chemical Progress." Sir Ray Lankester, three lectures: "Flints and Flint Implements." Sir Alexander C. Mackenzie, three lectures: 1. "The Beginnings of the Orchestra and its Instrumental Combinations;" 2 and 3. "Chamber Music and its Revival in England." Professor W. H. Bragg, two lectures: "X-Rays and Crystals:" 1. "New Methods of Research;" 2. "First Results and their Applications" (the Tyndall lectures). Professor H. S. Foxwell, two lectures: "The Finance of the Great War: New Problems and New Solutions; How We Stand To-day, and What Lies Ahead." Professor Sir James G. Fraser, two lectures: "Folk-Lore in the Old Testament." The Friday evening discourses will be resumed on May 5. Sir James Mackenzie Davidson, "Electrical Methods in Surgical Advance;" Arthur C. Benson, "Vulgarity;" Colonel Edmond H. Hills, "The Movements of the Earth's Pole;" Professor Charles G. Barkla, "X-Rays;" Ernest Clarke, "Eyesight and the War."

NATIONAL GUARD MECHANICAL TRANSPORT COLUMN.—In view of the imminent recognition of the Volunteer Corps by the Government, the work of the Mechanical Transport Column of the City of London National Guard in the near future will no doubt be followed with keen interest. The Column has done much useful work in the past in the transport of troops and stores in connection with trench-digging and field exercises, in the conveyance of wounded soldiers, doctors and ambulance men, and in drawing up and adopting, after consultation with War Office officials, special transport-infantry drill. Several convoys of lorries, which have been placed at the disposal of the National Guard by a number of makers and owners, will participate in the Easter manœuvres of the Guard at Brighton, under the command of Commandant E. S. Shrapnell-Smith, and between thirty and forty lorries (the majority, which are of the approved War Office type) will leave London on Thursday, April 20, returning from Brighton on Easter Monday. The vehicles already promised include the following makes:—Albion, Commercar, Daimler, Hallford, Leyland, and Thornycroft. Owners of lorries who are willing to assist with the loan of vehicles are invited to communicate with Column Commander and Adjutant F. G. Bristow, C.M.U.A., Offices, 83, Pall Mall, London, S.W.

THE NEW CHEMISTRY BUILDINGS OF UNIVERSITY COLLEGE, LONDON.

PROFESSOR F. M. SIMPSON, F.R.I.B.A., ARCHITECT.

Fig. 1. GROUND FLOOR & MEZZANINE PLANS.

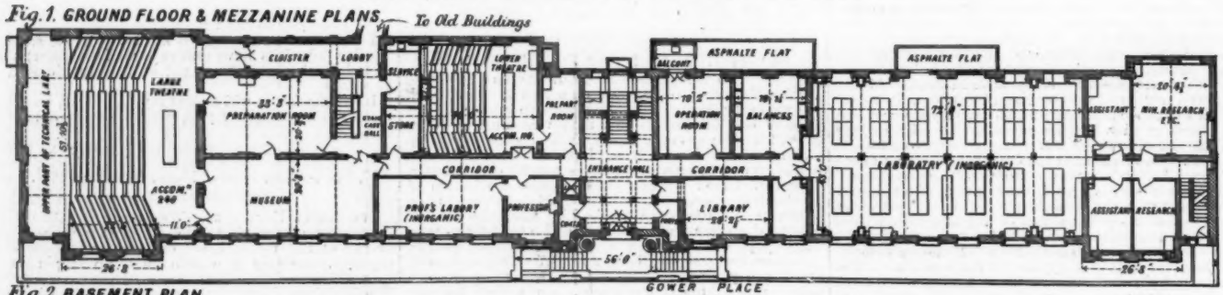
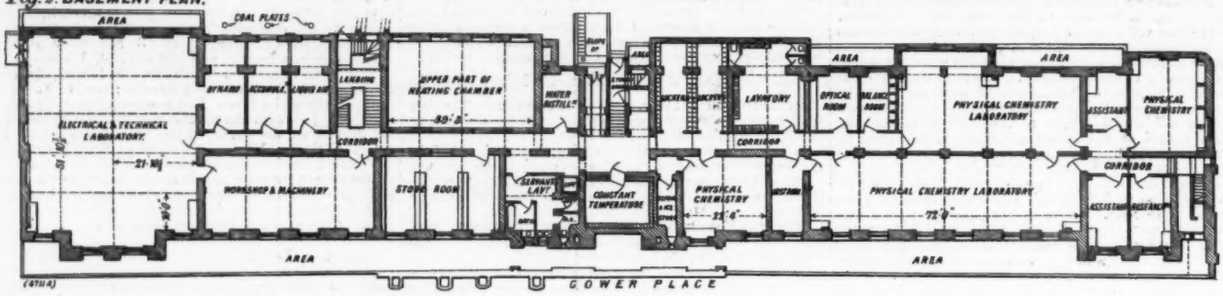


Fig. 2. BASEMENT PLAN.



THE paramount importance of chemistry in war and peace, in the household as well as in nearly all branches of industry and trade, has been harshly impressed upon the country in these days. The fact is recognised, but the reasons are not understood. The proverbial man in the street, who may have a seat in Parliament, admits that certain branches of chemical manufacture, especially those probably which did not promise any immediate return, have been neglected; but the remedy, he considers, is easy. The nation commands the raw materials, the works, the means, the brains, and competent chemists—let them start at once to manufacture whatever is wanting. But when he hears that University College, where renowned chemists like Thomas Graham, Alexander Williamson, and William Ramsay have taught, has been spending large sums on building splendid new chemical laboratories, and now appeals to the public for contributions to the equipment fund, the citizen shakes his head and mumbles something about there being other urgent needs in these times.

Though the new buildings were, of course, planned, and, in fact, almost finished, before the war broke out, the authorities of University College by no means regret having incurred this heavy responsibility when the country was enjoying peace. To draw the attention of the public to the urgency of their appeal, they arranged for an informal inspection of the new laboratories last Friday. As treasurer of the Equipment and Endowment Fund, Captain the Hon. Rupert Guinness, C.B., M.P., urged that the moment was not at all inappropriate for an appeal; the war would come to an end some day, and they had to provide for the time after it. The director of the laboratories, Professor Norman Collie, F.R.S., who has occupied the Chair of Organic Chemistry since 1902, stated that the extensions had been forced upon them; they had had to turn chemical students away for years, and after the war there would be more chemists than ever, more in particular demanding instruction in physical chemistry. Professor F. G. Donnan, F.R.S., an old University College student, who succeeded Sir William Ramsay as Professor of Inorganic Chemistry in 1913, added a few very significant words as to the meaning of technical chemistry, which the laboratories are to cultivate, a term which seemed to puzzle the British nation. Properly speaking, there was no such thing as technical chemistry; there were engineering chemistry and manufacturing chemistry; but before the chemist and physical chemist could call in the aid of the engineer to lay down an experimental plant, previous to passing the work on to the manufacturer, they had to submit the details of the operations to the closest chemical and physical study, and for all those purposes they required the most perfect laboratory equipment. Post-graduate research work is to be one of the features of the new laboratories.

The laboratories might appropriately be styled a chemical institute, as the plans, Figs. 1 and 2, will indicate. The chemical laboratories proper have been in use since last autumn, when the old laboratories were abandoned; but the other rooms are waiting for their fittings. University College men are justly proud of their college, with its imposing portico and dome, and any extension, however desirable on general grounds, of the buildings out of harmony with the original design would call forth a storm of indignation. No parts of the college can look back a century; the main buildings were only finished in 1838. The designer, William Wilkins, had been guided by the aspirations of Wren, and in designing the extensions of 1880, the two side wings with their projections along Gower-street, Hayter-Lewis followed the original plan. The additions of the last few years are the work of the present Professor of Architecture of University College, Mr. F. M. Simpson, who hopes some day to close the still open quadrangle and the gap in the Gower-street frontage by a screen of columns. The new architecture building forms the north-west corner of that quadrangle; the new chemistry building, with which we are dealing, lies outside the quadrangle, to the north of it and a little asymmetrically to it; that was unavoidable, Gower-place being not quite at right angles to Gower-street. There was another narrow street, called Little Gower-place, between Gower-place and the main college; that thoroughfare has now disappeared, and a covered bridge leads from the ground floor of the chemistry building into the north cloisters of the college. Messrs. Dove Brothers erected the building.

FIG. 3.

The handsome Portland-stone façade of the chemistry building, with its beautiful entrance, the doorway on a podium with Corinthian columns, placed distyle *in antis* (Fig. 3), well maintains the traditional character of the college buildings. The frontage has a length of 315 ft., and the building covers an area of 17,000 sq. ft., to a height of about 60 ft. The door, of oak studded with brass nails, opens into a spacious hall, out of which the main stairway, flanked by a pair of Ionic columns, leads to the upper floors; there are two other stairways. The plans (Figs. 1 and 2) show that the

THE NEW CHEMISTRY BUILDINGS OF UNIVERSITY COLLEGE, LONDON.

PROFESSOR F. M. SIMPSON, F.R.I.B.A., ARCHITECT.

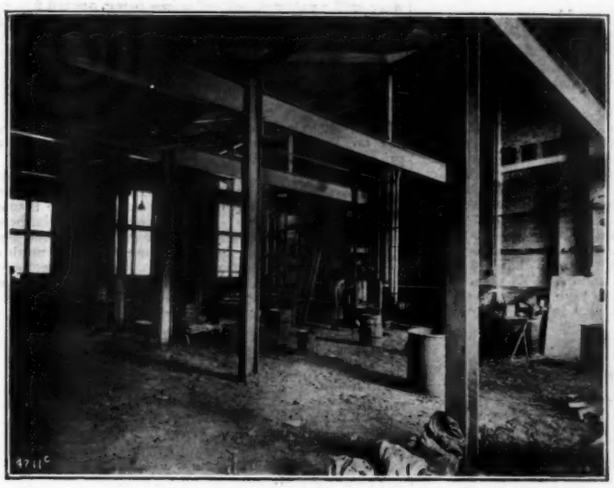


FIG. 4.

FIG. 5.

front is set back about 10 ft. from the inner line of the pavement. The lower half of the basement rooms is below the street level, and if it were not for the open area in front, those rooms would suffer from the gloom of underground dwellings. There is really a half-basement, hence; and as the lower windows are made of prismatic glass or of luxfer glass, which will distribute the light, there was no difference to be noticed in the brightness of the illumination in the basement and on the first floor, though the day on which the visit took place opened the spell of warm sunshine which followed the last snowstorm.

The planning of the interior was settled by the architect in conjunction with the members of the chemical staff who had beforehand made a tour of inspection of the chief modern laboratories at home and abroad. We have already mentioned the names of the two professors. Professor Donnan had already had a large share in the design of the Muspratt Laboratory at Liverpool University, from which he returned to Gower-street in 1913. To these we have to add the names of Dr. W. B. Tuck, Administrator of the Laboratories, who has had a great deal to do with the design and its execution, and Dr. S. Smiles.

The plans give a good idea of the great number of laboratories, lecture-theatres, and rooms. Generally speaking, the basement is given up to technology, the ground floor to inorganic chemistry, the first floor to organic chemistry, and the second, or top, floor to physiology and to the laboratories for first-year students. On all the floors accommodation is reserved for special research work. Beginning our inspection at the eastern end of the basement, we notice first the general laboratory for technical research on a large scale. It is a big room, 50 ft. square, taking up, like the large lecture-theatre just above it, the full width of the building. The floor will be concreted; the ceiling slopes, the maximum height being 27 ft. The photograph, Fig. 4, shows three openings of the special ventilation flues in the end wall, and the steel beams and stanchions are of the type used throughout the building. Pipes bring water, steam (for heating and other purposes), gas and compressed air into this as into most of the other laboratories. These pipes are lagged with cork if necessary, and are distinguished by rings of different colours; generally the pipes are placed in conduits; additions like the wires for electric power transmission will be attached to the ceilings.

As the water-main pressure would be insufficient for working vacuum pumps on the top floor, or driving water turbines or any other apparatus requiring more than 30 lb. water pressure per sq. in., hydraulic water under 700 lb. per sq. in. is mixed by an injector with supply water in an accumulator under load, so that a pressure of at least 75 lb. per sq. in. is available throughout the building. The injector pump and water look to prevent high-pressure unfiltered water getting back into the water mains were supplied by Messrs. Merryweather. The alternative would have been to boost the pressure by mechanical means; the automatic arrangement adopted seemed preferable. The apparatus seen in the photograph, Fig. 4, belong to an installation fitted up for the technical examination of a new manufacturing process. That research was entirely successful, and the Government factory which was started on the strength of this research has been in working order for some time. In the Organic Laboratory, we should here mention, some valuable drugs, greatly in demand in hospitals, are being made for the Government.

The Technical Laboratory is at the end of a cemented corridor running along the middle of the floor. The first front room next to it is the workshop, which is also used by the Physical Department. Then follow store-rooms, and underneath the main entrance—which is, so far, not used—the constant-temperature room, which is double-walled, with an air-space of about 6 in. between the two walls, and which will be electrically heated. On the other side of the corridor are the furnace, dynamo, accumulator, and liquid-air rooms; in the latter, the old Hampson liquefying machinery is to be reinstalled, and apparatus for liquefying hydrogen are to be added; liquid hydrogen has become indispensable in a good laboratory. The chambers and the stores for coke, corrosive and inflammable chemicals, &c., are underneath these rooms, and belonged to the cellarage of the houses that stood on the site. The other side of the floor, beyond the stairway, is taken up by the laboratories for physical chemistry. Fig. 5 is a photograph of one of these laboratories. The rooms are fitted up to accommodate a few workers, from one to three each.

On the ground floor are the large lecture-theatre, which has seating accommodation (tip-up seats) for 240 persons, and also the smaller lecture-hall for 110 senior students especially of physical chemistry, both of which extend into the first floor above. The large theatre is panelled with Oregon pine, and has been fitted up with spacious approaches, so that it may serve as a public lecture-hall. It is noteworthy that the floor above the large theatre is "hung up" from the girders of the asphalt flat above the large laboratory on the second floor; thus columns could be dispensed with in the theatre. The preparation rooms, a museum, and the private laboratories of Professor Donnan take up the eastern side of the main stairway, while the general inorganic laboratories, the assistants' rooms, operation-rooms, research-rooms, and library are on the western side. The name "operation-rooms" indicates rooms in which experiments involving much noise and objectionable fumes are carried out. The flooring of the laboratories consists of boards resting on beams supported by concrete, from which the boards are separated by 3-in. air-space. Wood is not an ideal flooring for a chemical laboratory; but concrete is cold and objectionable, while the boards are warm, and may easily be taken up when they need repair or when anything goes wrong in the drains (acid-proof, open conduits, made by the Leeds Fire-Clay Company, with bitumen joints). The benches are mostly covered with reddish-brown adamantine tiles (supplied by Messrs. Edwards, of Ruabon); these unglazed, highly-compressed tiles rest on a few inches (about 2 in. mostly) of ferro-concrete, which is supported by glazed bricks or wood, and they have given every satisfaction. It was feared that there might be more breakage of glass vessels on these stone tables than on the teak wood or slate otherwise used in the laboratories; but there have been no complaints at all in this respect, and the tiles are, of course, very easily kept clean and neat. The fume cupboards inside the rooms are merely ventilated by gas flames in the ordinary way; the large cupboards outside are ventilated by fans on the roof, driven by electric motors.

The first floor is similarly subdivided into organic laboratory, combustion, balance-rooms, double-doored dark rooms (there is one more of these in the basement), research-rooms, and the private laboratories of Professor Collie. The lecture-hall, which seats 110 students, reaches into the second floor. This top floor contains in its eastern portion the organic and inorganic laboratories for first-year students, which are the brightest rooms in the whole building, light being admitted through large skylights in the flat roof and in its sloping sides. The western portion is the department of Physiological Chemistry, under the direction of Professor Vaughan Harley; the general laboratory, the operation and post-mortem rooms, the small rooms for animals, and the large research-rooms, are intended only for post-graduate work. All the research-rooms, which are more or less isolated from other parts, are approached by the western staircase, which has a special entrance in Gower-place, while the eastern stairway serves the lecture theatres. The inside walls of most of the rooms are lined with glazed bricks, along which and the other walls run teak ledges for the various pipes.

The largest needs yet to be supplied concern the electrical and the physico-chemical equipment. So far current is available only for lighting, and there are no electric furnaces nor electro-chemical apparatus, we believe. Physical chemistry requires many elaborate apparatus. A sum of 20,000*l.* is now wanted for the equipment. Sir Ralph C. Forster, Bart., already the most liberal donor of 34,000*l.*, has promised to supply a quarter of the equipment sum, provided the other three-quarters be secured. Other donors are the late Mr. Otto Beit (5200*l.*); the Earl of Rosebery (Chancellor of the University), Viscount Iveagh, the late Sir Edward Durning-Lawrence, the late Dr. L. Mond, Mr. Edwin Tate, the late Sir Julius Wernher, the Goldsmiths' Company (each of these having contributed 1000*l.*), and many others; the London County Council voted 25,000*l.* towards the completion of the laboratories. It would be a very serious matter to let an institution of so widely recognised ability, upon which so much has already been spent, be crippled in its activity for want of final support, and we hope that the Hon. Rupert Guinness, M.P., the treasurer of the Equipment Fund, University College, will not have to issue a further appeal.

ARMOURED CARS FROM AUSTRALIA.—The first armoured motor-car for fighting purposes to be built in the Commonwealth is now completed, and several others are under construction. Considerable difficulty was experienced in procuring the required type of steel for the armour-plating, but finally this was overcome. The completed car weighs 1½ tons, and has a speed of 50 miles an hour. She is known by her crew as "Gentle Annie."

CROSS-COMPOUND WINDING-ENGINES FOR THE CHISLET COLLIERY, NEAR CANTERBURY.

On Plate XXXI. we give details of the cylinders of the powerful winding-engines built by Messrs. Fraser and Chalmers, Limited, for the Chislet Colliery, near Canterbury.

The general arrangement of the engine has already been illustrated in our last issue by Figs. 1 and 2, Plate XXIX. Details of the high-pressure cylinder are illustrated in Figs. 3 to 11, Plate XXXI., and of the low-pressure cylinder in Figs. 12 to 20. The high-pressure cylinder is not jacketed; it has a bore of 2 ft. 8 in., that of the low-pressure cylinder being 4 ft. 5 in., and the stroke of both is 66 in. Both are cast from hard, cold-blast iron. The cylinder clearances are in both cases about 5 per cent. Both cylinders are mounted on sole-plates of cast iron.

The valve arrangement of this engine is believed to be novel. As it is intended to work with superheated steam, it was considered inadvisable to employ Corliss admission-valves, on account of lubrication difficulties. Moreover, when applied to winding engines, particularly if compounded, Corliss valves are somewhat liable to rattle on their seats when the throttle-valve is closed in finishing a run or wind. In the case of the inlet valves, this is due to the pressure in the cylinder rising above that in the steam-chest, whilst in similar fashion the exhaust-valves lift if the pressure in the cylinder falls below that in the exhaust-pipe. The rattling does not, it is true, really damage the valves, but the noise is objectionable. For these reasons, it was decided to make the inlet valves of the drop type, but to retain the Corliss pattern for the exhaust-valves. These have not to work under the same extremes of temperature and pressure as the admission valves, whilst there are some serious objections to the use of the drop type as exhaust-valves. If reasonable cylinder clearances are to be retained, it would be necessary to locate these drop-valves immediately under the cylinder and below the floor of the engine-room. The relative inaccessibility of valves thus placed, and the awkwardness of inspecting them, commonly leads to their neglect by the engineman, so that there is great risk of trouble sooner or later. The Corliss valves, on the other hand, are above floor-level, and easily accessible. All four valves, both drop and Corliss, are operated by a wrist-plate which is driven from the usual eccentrics by an Allan straight-link motion.

A reheater receiver is placed between the two cylinders and below the engine-room floor. In this the steam discharged from the high-pressure cylinder is reheated by live steam drawn from the boiler. This receiver is fitted with wrought-iron tubes expanded into tube-plates, and through these the steam passes on its way to the low-pressure cylinder, whilst the live steam surrounds the tubes. A relief-valve is fitted to prevent any dangerous rise of pressure.

Throttle-valves controlled both by hand and by governor-gear are fitted to both cylinders, and above them instead of below the floor. In this way the valves are immediately accessible and ensured of due attention. Both valves are opened and closed simultaneously. In actual winding operations sufficient steam is trapped in the reheater receiver to ensure the immediate restarting of the engine when required whatever the position of the cranks. It is thus unnecessary to pass live steam direct to the low-pressure cylinder, unless, possibly, after a very prolonged stand. This arrangement is one of the many improvements in winding-engines which have originated with Messrs. Fraser and Chalmers, and since been adopted by others.

An enlarged detail showing the thickness of the high-pressure cylinder and the depth of the heavy box-section covers is reproduced in Fig. 10. These covers have no flanges, but are held in position by the flanges of the front and back guide-frames, which are secured to the cylinder heads by twenty 1¼-in. studs. The joint is made good by copper rings caulked in as indicated. The throttle-valve is secured to the cylinder at A, Figs. 3 to 6, and from this valve the steam enters the large receiver space shown, which communicates at each end with the valve-chests. A cross-section through one of the valve-chests is represented in Fig. 3. A detail of the valve-seat is shown in Fig. 8, whilst Fig. 9 shows the studs used to strengthen the cylinder at the exhaust-ports. Two studs are used for each of these ports. The flanges on the side of the cylinder to support the wrist-plate and other operating mechanism are well shown in Fig. 5.

The Corliss exhaust-valves both communicate with an exhaust branch, 14 in. in diameter, situated midway between them. From each valve there is a branch C, Figs. 4 and 7, which leads to a relief valve. As indicated by the key plans, Fig. 11, the high-pressure cylinders for the two engines, being built for the colliery, will be right and left handed respectively.

As will be seen from Figs. 12 to 20, the details of the low-pressure cylinder are very similar to those of the high-pressure cylinder; the main difference is that the low-pressure cylinder is jacketed. The liner is of the same metal as the body of the cylinder. It is turned to a forced fit, and further secured by copper rings caulked in at each end. As will be seen from Fig. 19, this liner abuts against a shoulder at one end only, so that it is free to expand at the other end.

(To be continued.)

NOTES FROM THE UNITED STATES.

PHILADELPHIA, March 22.

ANOTHER general advance in steel products outside of steel rails has taken place, ranging from 2 dols. to 5 dols. a ton. Further advances seem inevitable. Buyers are undetermined whether to place orders for distant delivery at current prices, or to defer action and take their chances on a possible recession in prices. Producers say that the buyers are forcing prices up on themselves. Export business continues to be a very important factor. The latest important inquiry aggregates 100,000 tons of barbed wire from England and France; other material for war munitions continues in active demand. Pig-iron, after a temporary lull, is once more in active demand. Ferro-manganese is nominally 175 dols. at seaboard with none available. As high as 350 dols. have been paid for spot delivery with 400 dols. asked for 80 per cent. The partial removal of the embargo to New England has brought out a large number of inquiries and orders. All finished material is moving upward, some buyers placing orders for 1917 delivery. Railroads continue active buyers of steel rails, cars and locomotives. Steel rail orders for the week aggregate 90,000 tons for delivery late this year and 95,000 tons for delivery next year.

Domestic orders have been placed for 4500 cars and 275 locomotives. Another inquiry is on the market for export for 25,000 cars. Bridge material for railroads is also very active. Heavy steel plates are called for far beyond the capacity of the mills. Prices are no consideration. Shipbuilders contract for material to cover prospective construction just as fast as they accept contracts. The railroads of the United States are facing a contest with their employees which involves extra annual payments of, in round figures, 100,000,000 dols., based upon an eight-hour day. It is impossible to make the average run in less than ten hours. Time-and-a-half is demanded for the extra two hours. This is the most serious problem the railroad managers have ever had to face. While their traffic has enormously increased, and while they might be able to pay it while exceptional conditions continue, the return to normal conditions would impose impossible burdens.

THE INCORPORATED MUNICIPAL ELECTRICAL ASSOCIATION.—The twenty-first annual and other business meetings will take place on June 22 and 23, at the Institution of Electrical Engineers, Victoria Embankment, W.C. On Thursday, June 22, after the Presidential Address by Mr. Alex. C. Cramb, Borough Electrical Engineer, County Borough of Croydon, the following three papers will be read:—"Boiler-House Design," by Mr. W. W. Lackie, Past-President, Engineer and Manager, Glasgow Corporation Electricity Department; "Area of Supply from an Economic Standpoint," by Mr. H. S. Ellis, Borough Electrical Engineer, South Shields; "The Application of Electric Power to Agriculture," by Mr. W. T. Kerr, City Electrical Engineer, Hereford. On Friday, June 23, the members will receive the Council's annual report, close the ballot for officers and Council, 1916-17, and transact other business.

THE INSTITUTE OF MARINE ENGINEERS.—The annual report of the Council, presented at the twenty-seventh annual meeting, on Friday, March 31, states that the membership at the close of the financial year, on January 31, 1915, totalled 1553, the net increase during the year being 86. Subjects were set for papers or essays for Sir Archibald Denny's award for sea-going members. For a contribution on "Nominal, Indicated, Brake and Shaft Horse-Power, how Ascertained, and their Relation to One Another," Mr. James Watt, Graduate, was awarded 2*l.*, and for contributions on "The Thrust Shaft; its Relation to the Work and the Power Transmitted; Design of an Ideal Thrust-Block, with Description of Details," Mr. C. P. Tanner was awarded 2*l.*; Mr. D. Langharne-Thornton, 1*l.* No examination was held during 1915, as most of the engineering apprentices, for whose benefit the scholarship was intended, are engaged on National Service. As it was decided to postpone the examination for these scholarships during the war, the amount of the scholarships—viz., 50*l.* per annum for two years—has therefore, with the approval of Lloyd's Register, been held over in the interim, allowing the scholarships to accumulate, and the names of accepted candidates have meantime been retained. The Chairman of Council was nominated by the Council to serve on the Committee in connection with the Advisory Council, appointed by the Board of Education for Industrial and Scientific Research. Mr. J. Shanks was nominated to represent the Institute on the Advisory Committee of the Board of Trade, to succeed the late Mr. Joseph Hallett. The Board of Trade desired the Council of the Institute to express an opinion on the formulation of a more definite basis for the calculation of nominal horse-power than is at present in use, and the matter is still under consideration. Mr. Alexander Boyle has been appointed as representative on the Committee formed by the Institute of Metals to conduct research work on the corrosion of metals. Mr. J. S. Blackett, member at San Francisco, was appointed to attend the International Engineering Congress at San Francisco, September 20 to 25, 1915.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Glasgow Pig-Iron Market.—Last Wednesday afternoon showed no change in the pig-iron market; business remained at a standstill, with the price of Cleveland warrants firm. On Thursday morning the conditions were still unaltered, sellers' prices being quoted 91s. per ton, but in the afternoon no declared sellers were in the market. Sellers' prices remained stationary on Friday, but no transactions took place either forenoon or afternoon; indeed, the work was completely blank so far as public business was concerned. This dulness still prevailed on Monday, the only difference being an advance of 1s. per ton in buyers' prices at the morning session, when 93s. was quoted. Neither at the afternoon session nor on Tuesday was any business transacted, sellers' prices remaining unchanged since Friday.

Scotch Steel Trade.—In Glasgow and the West of Scotland, despite the unfortunate friction which has caused much anxiety, the steel industry continues to flourish with the utmost vigour, the output of war material being well maintained, and the prices continuing at the high level, which shows no signs of easing off. The needs of our own Government, those of our Allies and our colonies, are increasing, and naturally have first claim on all workers, and only after these demands are satisfied is it possible for steel-makers to consider the claims and necessities of ordinary mercantile customers, and in this direction business is therefore slow. In view of the urgent necessity makers are doing their very utmost to grapple as successfully as possible with the problems with which they are faced, and at several of the local works new smelting-furnaces are being erected in order to cope with the demand for semi-finished steel material. In some cases prices have advanced, owing to the ever-increasing cost of raw material and of labour, and the current quotations for boiler and ship-plates and for angles are a trifle over last week's level.

Malleable-Iron Trade.—There is an extraordinary demand for malleable iron of all kinds, and makers report excellent business, especially in the smaller sizes, which are required, either directly or indirectly, for Government purposes. In the circumstances it is becoming increasingly difficult for any mercantile orders to be undertaken. For prompt delivery "Crown" bars are firm at 14*l.* per ton, less the usual 5 per cent. discount, and for export the figure is about 13*l.* 10*s.* net.

Scotch Pig-Iron Trade.—The home trade in Scotch pig-iron keeps on a very high level, although little is being put through on export account, particularly in the case of ordinary foundry iron, which is much quieter than usual. Hematite is in such continual demand for the home markets that it has been deemed advisable greatly to curtail its export, even to Colonial consumers. Since the maximum price was officially settled a few weeks ago, the price of foundry iron was taken into consideration also, and the decision has just been made public. For No. 3 grade at works 5*l.* 15*s.* 6*d.* per ton has been fixed, 2*s.* 6*d.* extra being allowed for delivery in Glasgow, while the customary 5*s.* per ton above this figure will be leviable on the No. 1 quality of all the best brands. With the lower-grade qualities makers may discount the official rating to the extent of 1*s.* 6*d.* per ton. So far export prices remain free. The current market quotations for makers' (No. 1) iron continue unchanged, the prices still being as follow:—Summerlee and Langloan, 125*s.* per ton; Clyde, Calder, and Gartsherrie, 127*s.* 6*d.* (all shipped at Glasgow); Eglinton, 120*s.*; Glengarnock, 125*s.* (both at Ardrossan); Dalmellington, 122*s.* (at Ayr); and Shotts, 127*s.* 6*d.* (at Leith).

Scotch Shipbuilding during March.—In comparison with former years, mercantile shipbuilding, particularly on the Clyde, continues poor, for very obvious reasons, only two vessels having been launched during the month of March. Taken in conjunction with January and February, this totals a net tonnage of 16,956 tons for the five vessels launched in the first quarter of the year, while for the corresponding period a year ago, twenty-nine vessels, of a net tonnage of 106,705 tons, were launched. Although the available figures are the lowest for a number of years, every yard in the Clyde area is as busy as it is possible to be, the demands of the Admiralty being excessive, and the pressure inordinate. Some mercantile orders are reported to be under consideration, and it is stated that Messrs. Barclay, Curle and Co., Whiteinch, have just had a contract placed for a cargo boat for the Federal Steam Navigation Company. The following table gives the figures for March:—

Clyde.	Forth.	Dee.
Two vessels	Three vessels	Three vessels
11,246 tons	2943 tons	615 tons

while those for the quarter figure out at:—

Clyde.	Forth.	Tay.	Dee.
Five vessels.	Three vessels.	None	Ten vessels
16,956 tons	2563 tons	—	1841 tons

EMPLOYMENT FOR DISCHARGED ARMY MOTOR-DRIVERS.—The Employment Bureau for Discharged Army Motor-Drivers, which was established by the Commercial Motor-Users' Association in 1915, with the co-operation of the War Office, the National Association for Employment of Ex-Soldiers, and the Board of Trade Labour Exchanges, has been the means of placing a large number of discharged drivers in direct contact with those firms in need of drivers for their commercial motor vehicles. Drivers are invited to register their names at once at the offices of the Association. Particulars and application forms of the Bureau, which is free to drivers, may be obtained from Mr. F. G. Bristow, F.C.I.S., Secretary, the Commercial Motor-Users' Association, 83, Pall Mall, London, S.W.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

South Yorkshire Coal Trade.—The general scarcity of fuel continues to perturb merchants and consumers alike. Except in cases under contracts, works are unable to get supplies, and are obliged to run with only sufficient for daily requirements. There are no reserves on hand, and even munition establishments are suffering from the shortage. The reports from the collieries show that better workings are now being maintained under the more favourable weather conditions, but this improvement is not of sufficient duration to exercise any direct influence upon the present state of the market. Another factor is the inducement offered to agents to secure orders for shipment, as in these cases the quotations are 3s. to 4s. per ton higher than the figures obtained for inland transactions. Recent shipments have been chiefly for French and Italian ports, but these have not been of an unduly heavy character. The tonnage for neutrals is small. Gas-coal of all description is going away freely to inland works on contract account. Only in the house-coal section is the position at all easier. In this respect the warmer weather is having the effect of lessening the rush of business, and merchants and agents are better able to deal with the vast accumulation of orders on their books. So heavy are these orders that it is estimated that if the situation is unchanged till Easter, the holidays will arrive with arrears still to be wiped off. Some hope is placed on the acceleration of output at the collieries; but as this seems to be entirely dependent upon the fine weather continuing, merchants are not over-sanguine that the general position will be appreciably eased until the advent of summer. It is satisfactory to note that the railway difficulties are not so acute. Quotations: — Best branch hand-picked, 20s. 6d. to 21s. 6d.; Barnsley best Silkstone, 17s. 6d. to 18s. 6d.; Derbyshire best brights, 17s. 6d. to 18s. 6d.; Derbyshire house, 16s. to 17s.; best large nuts, 15s. 6d. to 16s. 6d.; small nuts, 15s. to 16s.; Yorkshire hards, 16s. 6d. to 17s. 6d.; Derbyshire hards, 16s. to 17s.; best slacks, 12s. to 13s.; seconds, 10s. 6d. to 11s. 6d.; smalls, 8s. to 9s.

Iron and Steel.—Sheffield is only slowly recovering from the effects of the storm. The city's industries were rather severely dislocated by the delayed deliveries of fuel, material, and finished goods, and some time must of necessity elapse before circumstances will become normal. There is a briskness all round, however, and all possible steps are being taken to minimise the loss of output. Steel works are running at full pressure, but even so, all requirements for war purposes cannot be met. The expansion of the work of national importance seems to continue unceasingly, and manufacturers are not aided in their tasks by the unsettling influence of the sifting of "badged" men. The market for iron and steel retains last week's firmness. Prices are now more settled than at any other period during this year, and there is no immediate likelihood of a change. Hematites are in a strong position and are keenly inquired after. Considerable business has been done at current rates. Common irons are featureless. The consumption of pig-iron is below the average of recent weeks. The meagre imports of billets are reflected in the high prices demanded. Basic billets are stated to be almost unprocurable, and for any spot lots fancy figures are paid. Recent transactions have been done at the following rates:—Bessemer acid, 14*l.* to 14*l.* 10*s.*; Siemens acid, 15*l.* 10*s.* to 16*l.*; basic hard, 12*l.* 10*s.* to 13*l.*; basic soft, 11*l.* 15*s.* to 12*l.*; steel hoops, 17*l.* 2*s.* 6*d.* Scrap is being used on an enormous scale, but as the supply is abnormally great, the quotations are much more in buyers' favour than they usually are. The general steel trade, apart from Government and similar work, indicates a falling-off in the near future, as the present inquiries are only on a small scale. Manufacturers are not alarmed, however, and some even look forward with relief to a slight easing of the present high tension. In the cutlery trade it is satisfactory to note that the export business is being maintained, notwithstanding the many difficulties which beset manufacturers. Only one-third of their original staffs are vouchsafed them by the Military, and it is a tribute to the business acumen of Sheffield cutlers that the position should show no falling away, especially in view of the mammoth Army and Navy contracts which have to be executed. On the other hand, there has been little change noticeable by the elimination of German competition, for American, and even Swedish, competitors have stepped into the breach. The foreign and colonial business is being conducted at high pressure. Recent orders were chiefly for saws, springs, tools, cutlery, and steel.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Pig-iron is becoming more and more scarce. Customers abroad are most insistent in their efforts to place orders for Cleveland iron, but they experience great difficulty in doing so, and the belief is growing that shipments to neutrals will be prohibited in the near future. At the same time it is satisfactory to know that, so far, the committee appointed to regulate supply to home consumers have not found it necessary to make any suggestion with regard to restriction of exports, in order to satisfy home requirements. Up to now consumers here are receiving supplies regularly. Practically the only stock of pig-iron is that in the public warrant stores, and the quantity held there is little over 50,000 tons, nearly all of which is No. 3 Cleveland. Business is very quiet. The export quotation of No. 3 Cleveland pig has risen to 95s. f.o.b., whilst that of No. 1 is in the neighbourhood of 100s., and No. 4 foundry, 94s. For home consumption, the fixed maximum of 82s. 6d. still rules for both No. 3 and No. 4 foundry.

Hematite Iron.—There is nothing new ascertainable concerning the East Coast hematite branch of the staple industry. With no iron on sale for supply earlier than the third quarter of the year, and makers not at all inclined to quote forward, business is practically at a standstill. Nominally the export quotation of Nos. 1, 2, and 3 is 140s., and the price for home consumption remains at the fixed maximum of 122s. 6d.

Foreign Ore.—As regards foreign ore business is possible on the basis of 17s. for 50 per cent. Rubio f.o.b. at port of despatch. Consumers buying for manufacture of iron to be used at home can arrange freights Bilbao-Middlesbrough through the Government at 17s., but in the ordinary way in the open market the freight is 26s. Imports of foreign ore to the port of Middlesbrough so far this month amount to 37,248 tons.

Coke.—There is no change in coke. Business is understood to be still passing at the fixed maximum for home use of 28s. at the ovens for average blast-furnace sorts, and up to 30s. 6d. at the ovens for qualities low in phosphorus.

Manufactured Iron and Steel.—No new features of moment are ascertainable concerning the finished-iron and steel industries. The numerous private inquiries in the market receive little attention from producers, all of whom continue too busy with Government work to entertain ordinary commercial business. The following are among the principal quotations:—Common iron bars, 13*l.* 10*s.*; best bars, 13*l.* 17*s.* 6*d.*; double best bars, 14*l.* 5*s.*; treble best bars, 14*l.* 12*s.* 6*d.*; packing iron (parallel), 10*l.*; packing iron (tapered), 11*l.* 15*s.*; iron ship-plates, 11*l.* 10*s.*; iron ship-angles, 13*l.* 10*s.*; iron ship-rivets (¾-in. diameter), 16*l.* 10*s.*; iron ship-rivets (⅝-in. diameter), 17*l.* 10*s.*; steel bars (no test), 14*l.*; steel ship-plates, 11*l.* 10*s.*; steel ship-angles, 11*l.* 2*s.* 6*d.*; steel ship-rivets (¾-in. diameter), 17*l.* 10*s.*; steel ship-rivets (⅝-in. diameter), 18*l.* 10*s.*; steel strip, 14*l.* 10*s.*; steel hoops, 15*l.*; steel joists, 11*l.* 2*s.* 6*d.*; and heavy steel rails, 10*l.* 17*s.* 6*d.*—all less the customary 2½ per cent. discount, except rails, which are net f.o.b.; and steel joists and steel shipbuilding material, which are net at works.

Iron and Steel Shipments.—The shipments of iron and steel from the Tees during March totalled 94,951 tons, as compared with 82,073 tons for the previous month, and 48,083 tons for March last year. Of last month's clearances, 62,010 tons were pig-iron, 6012 tons manufactured iron, and 26,929 tons steel. Only 875 tons of pig-iron went coastwise, 61,135 tons going to foreign ports. France received no less than 31,845 tons; whilst Italy took 9587 tons; Norway, 4942 tons; Denmark, 4667 tons; Sweden, 2950 tons; America, 2400 tons; and Japan, 2274 tons. Of the manufactured iron despatched during the third month of the year, 4341 tons went to coastwise customers and 1671 tons to buyers abroad, India, with an import of 850 tons, being the largest receiver. Of the steel cleared, 26,144 tons went foreign and 785 tons coastwise, the principal customers being France, 21,419 tons; Japan, 1743 tons; and India, 1678 tons.

NOTES FROM THE SOUTH-WEST.

Cardiff.—Colliery-owners, anticipating that there would be considerable tonnage arrivals over the week-end, have not been disposed to modify quotations for early April deliveries. It will take some weeks fully to restore telegraphic communication, which suffered from a recent blizzard; but every day may be expected to be attended with some progress in this respect. Buyers are showing a disposition to hold back inquiries in the hope of values becoming easier. The best Admiralty large steam coal has been, to some extent, nominal; secondary qualities have made 38s to 40s.; best bunker smalls, 20s. to 21s.; and cargo smalls, 14s. to 17s. per ton. The latest quotations for bituminous coal and patent fuel have been:—Best households, at the pit, 23s. to 24s.; No. 3 Rhondda large, 34s. to 36s.; smalls, 22s. to 23s.; No. 2 Rhondda large, 31s. to 32s.; No. 2 smalls, 17s. to 18s.; and patent fuels, 38s. to 40s. per ton. Special foundry coke for export has been quoted at 57s. to 62s. 6d.; good foundry coke, 52s. 6d. to 57s. 6d.; and furnace coke, 42s. 6d. to 47s. 6d. per ton. As regards iron ore, Rubio has been quoted at 39s. to 40s. per ton, upon a basis of 50 per cent. of iron, and charges, including freight, insurance, &c, to Cardiff or Newport.

Western Trade Matters.—The Nantyglo and Blaina Iron Works Company, Limited, will pay 3*l.* per preference share, April 14, in reduction of arrears of dividends upon its preferences; the arrears have been running on since 1872, and now exceed 500,000*l.*—A special meeting of the Moindy Shipping Company, Limited, has unanimously approved an increase of the nominal capital of the company from 50,000*l.* to 200,000*l.* It was shown at the meeting that the company was making considerable progress, and that the engagement of its existing tonnage would place it at the close of the ensuing financial year in the position of having approximately written down the cost of its steamers. It was further stated that contracts had recently been let for two steamers, each to carry 7250 tons dead weight, and also another steamer to carry 3750 tons dead weight. It was confidently anticipated that these three steamers would be delivered during the next twelve months, by which time the average cost of the fleet would be under 8*l.* per ton of issued capital.—The old Cyfarthfa Iron Works at Merthyr will be shortly re-opened; the principal difficulty is that of labour, but the services of upwards of 100 men have now been secured.—Messrs. Bailey, of Newport and Barry, who are endeavouring to obtain the financial control of the Cardiff Junction Dry Dock and Engineering Company, Limited, offer 9*l.* 11*s.* 8*d.* per share for the fully-paid shares, and 8*l.* 11*s.* 8*d.* per share for the 4*l.* paid shares. The intending purchasers make it a condition that they shall acquire at least 85 per cent. of the share capital, and that the purchase shall be completed by May 4.—The death is announced of Mr. G. Deer, chairman of the Rhondda and Swansea Bay Railway Company. He was born in January, 1854, at Skewen, near Neath, and his family was long and honourably associated with the industries of South Wales. He was for some time associated with the Cape Copper Company, and in 1888 he took charge of the blast-furnace plant of the Rio Tinto Company in Spain. He returned in 1895, and became manager of their extensive works at Cwmavon, Port Talbot. When the Rio Tinto Company erected new works at Port Talbot, Mr. Deer made visits of inspection to Germany and the United States, so as to bring the Port Talbot enterprise thoroughly up to date. He succeeded Mr. M. B. Williams as chairman of the Rhondda and Swansea Bay Railway in 1911.—The Cymric Shipping Company, Limited, has declared an interim dividend for the first quarter of the year at the rate of 30 per cent. per annum.—At the monthly meeting, on Friday, of the Newport Chamber of Commerce, Mr. F. P. Robjent spoke in favour of Government subsidies for the advancement of trade at home and abroad. Mr. Robjent contended that a representative of the Government should sit continuously to examine trade proposals of national importance, and that if a subsidy of 30,000*l.* or 100,000*l.* were desirable for financing such proposals, not so much in the interest of the promoters as of the country, such a subsidy should be granted.—The Tenypas Shipping Company, Limited, gives its shareholders a dividend of 30 per cent. for the year ended March 31.—Some four years ago borings were commenced at Presteign for coal. Indications of coal-seams were developed; but in consequence of the war it has been decided to abandon the enterprise for the present.—A meeting of the members of the British Dockers' Union was addressed by the Lord Mayor of Bristol (Dr. Barclay Baron) and Mr. Alderman Twiggs, chairman of the Docks Committee of the Bristol City Council. Mr. Twiggs argued that the great thing to be done was to reduce to a minimum the laborious and brutish part of the work by employing the best mechanical forces. As this reduced the cost of production, men were able to secure higher rates of pay for guiding new mechanical forces with skill and intelligence. The higher rates of pay were obtained in those industries in which the highest forms of mechanical appliances were used, and those ports which had the latest and best equipment secured trade, while commerce passed away from ports which were obsolete and behindhand in their methods and ways. In the rearrangement of the world's business Bristol must keep its eyes open, but no port was better adapted for expansion. At Avonmouth there was room on vacant land to the east of St. Andrew's-road for the accommodation of large works. Within the dock premises there was also land for large factories for the treatment of raw materials from abroad. At Bristol Docks there was as fine a body of men as could be found at any docks in the kingdom; and it was encouraging to find that the volume of goods imported had increased last year to 2,774,427 tons, as compared with 2,106,848 tons in 1901.

THE RAILWAY YEAR-BOOK, 1916.—We have received a copy of this year-book for the current year, the nineteenth year of publication; it is published at the office of the *Railway Magazine* at the price of 2s. 6d. net. It contains general information on the British railways in regard to finance, statistics, &c., and each British railway is dealt with separately, a map being given of each system, together with the names of the directors, chief officers, an historical sketch, and very complete data on the system, its working, and the financial results. General information is also given on the railways of the world. The book forms a useful and interesting compendium on railway matters.

THE BEAR ISLAND COAL DEPOSITS.—The Bear Island coal deposits have been geologically examined, and they are understood to contain almost inexhaustible supplies of coal. Samples have been tested at the Mining Academy in Berlin, and the quality has been found most satisfactory. The heating value is given as 14,580 B.Th.U., whilst with ordinary English coal it is about 12,000. Preparatory work has already commenced; a couple of men have spent the winter at Bear Island, and a couple of engineers are going up to prepare the plans for harbour construction, transport arrangements, store-houses, &c. The Bear Island is open for navigation throughout the year, and the harbour will, it is stated, require no very heavy expenditure.

THE VIZCAYA IRON AND STEEL WORKS.—We read in the *Revista Minera, Metalurgica y de Ingenieria* that the Sociedad de Altos Hornos de Vizcaya is building new shops for dealing with large steel forgings for the manufacture of medium-calibre guns, shafts, &c. The new shops will cover an area of 4800 sq. metres (51,670 sq. ft.). They are to contain two hydraulic forging-presses of 2000 and 800 tons, served by two electric travelling-cranes provided with the necessary gear for revolving the pieces in the forging treatment. The necessary machinery is being built in the United States. A special shop is to be set apart for the heat treatment of forgings, especially of those for the construction of guns, and is to contain large horizontal and vertical furnaces, and a deep hardening-pit full of oil, served by a quick-acting electrically-driven crane.

THE NEW RHONE-MARSEILLES CANAL.

(*For Description, see Page* 316.)

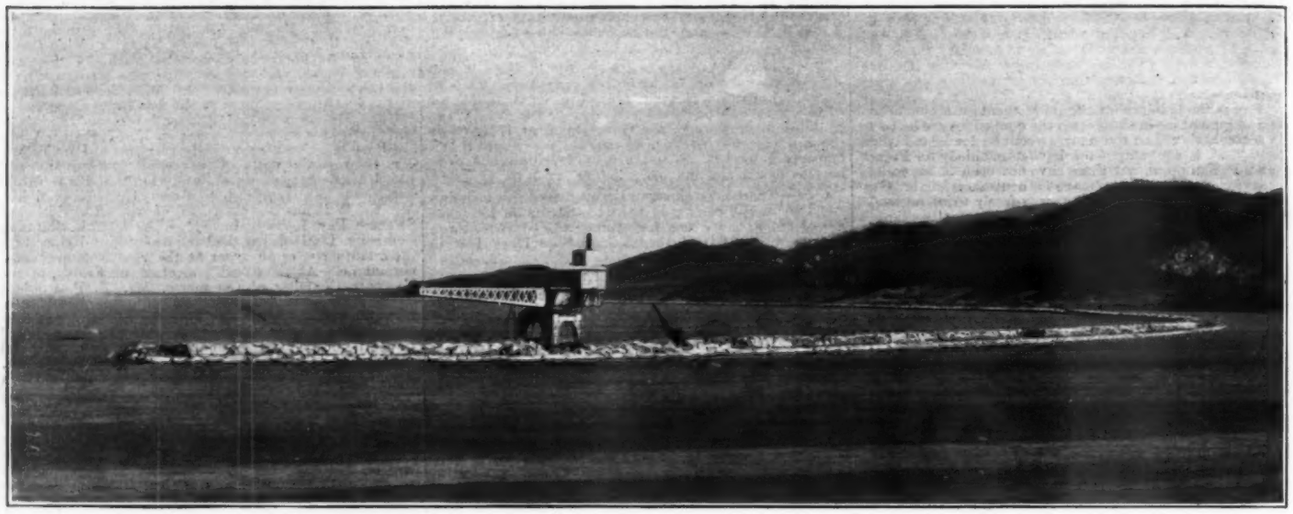


Fig. 15. Dyke between the Sea and Canal from Marsellles to La Lave.

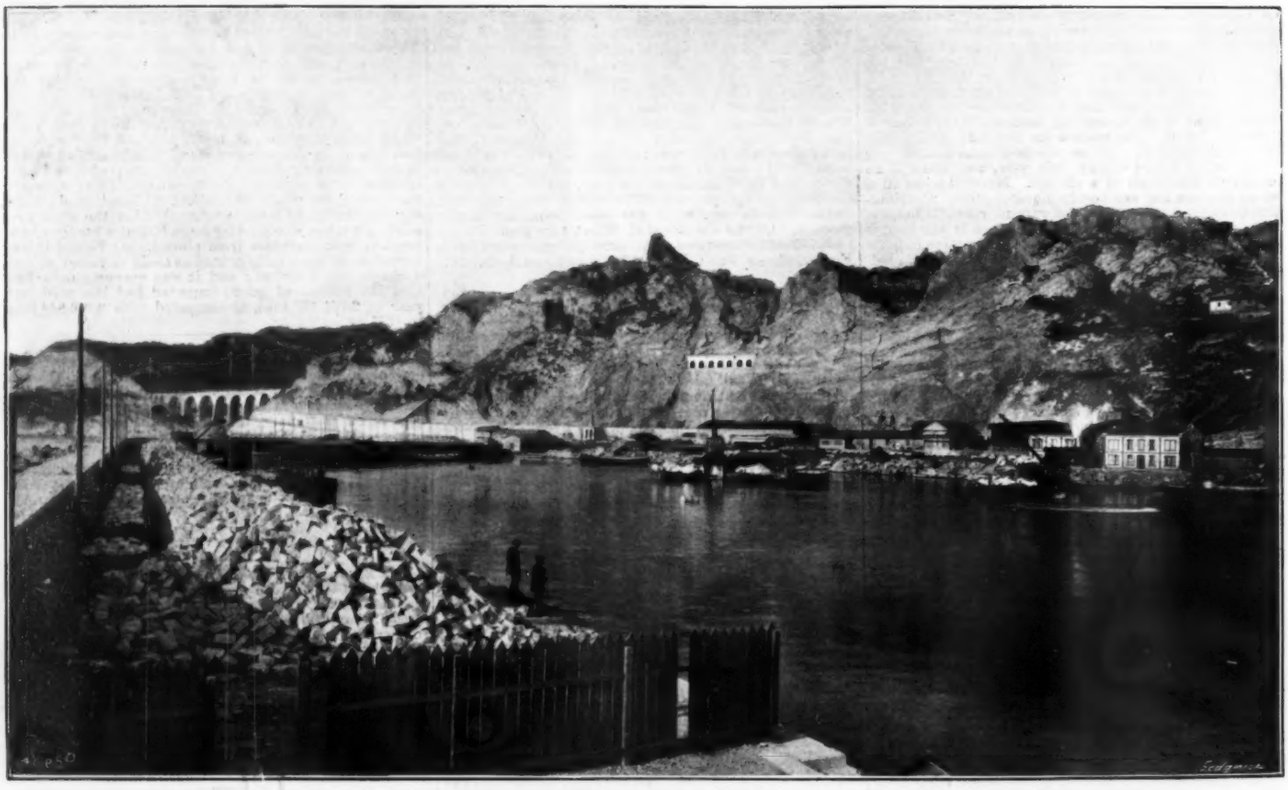


Fig. 16. Entrance of Canal Tunnel at Port de La Lave.

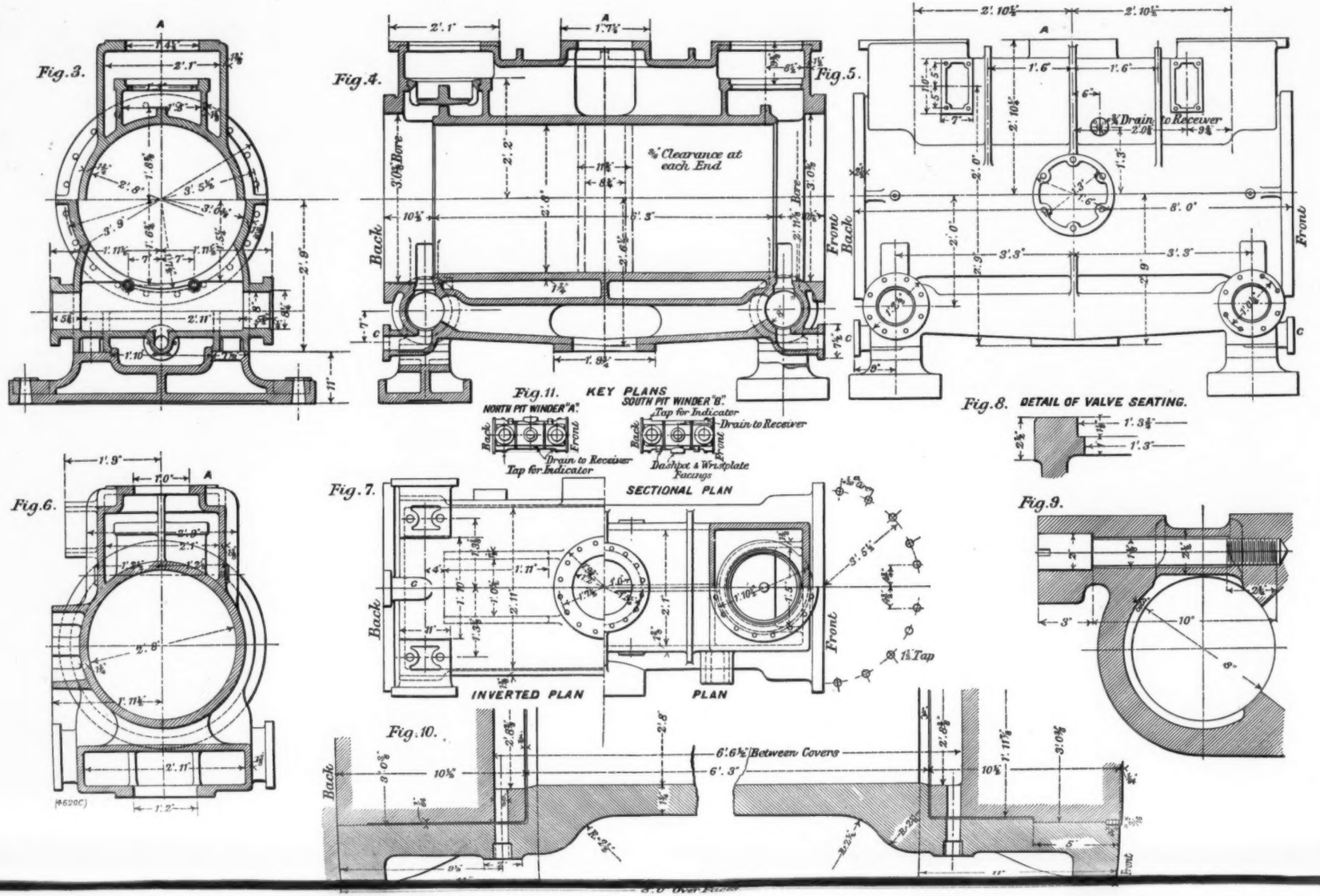
A Railway Veteran.—The death is announced, in his ninety-third year, of Mr. T. Normington, formerly well known as a railway official, and for thirty-six years district superintendent of the Yorkshire Division of the Lancashire and Yorkshire system. Mr. Normington entered the service of the Lancashire and Yorkshire (then the Manchester and Leeds) Railway in January, 1847, in the comparatively humble capacity of parcels porter at Brighouse. At that time the Lancashire and Yorkshire Railway had no completed line to Bradford, and passengers had to alight at Brighouse, and were sent on in omnibuses. The Low Moor and Bradford extension was opened in 1850, in which year Mr. Normington had risen to the post of guard. In 1854 he was appointed station master at Sowerby Bridge; in 1859 he became assistant superintendent of the Yorkshire Division under Captain Binstead, whom he succeeded upon that official's retirement. He retired himself from the Lancashire and Yorkshire service in June, 1895, when he had reached his seventy-first year.

American Pig.—Of the 29,916,213 tons of pig-iron produced in the United States last year, 8,583,007 tons were made for sale, and 21,333,206 tons for current consumption. In 1914 the aggregate production was 23,332,244 tons, and 7,362,980 tons were made for sale. In 1913 the aggregate outturn was 30,966,152 tons, of which 9,523,385 tons were made for sale. To put the matter in other words, there is more steadiness and force in production for current consumption than there is in production for sale, as the element of chance enters into the latter, while it is almost entirely absent in the former. While the total production of pig in the United States was 1,050,000 tons less in 1913, the production of Bessemer, spiegeleisen, and ferro-manganese showed a falling-off of only 513,000 tons.

CYLINDERS FOR CROSS-COMPOUND WINDING-ENGINE FOR THE CHISLET COLLIERY, NEAR CANTERBURY.

CONSTRUCTED BY MESSRS. FRASER AND CHALMERS, LIMITED, ENGINEERS, ERITH.

(*For Description, see Page 324.*)



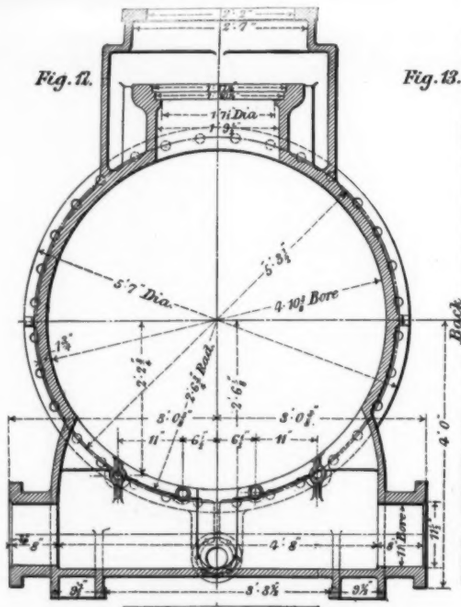


Fig. 11.
5'7" Dia.
4'10½ Bore
5'0¾"
3'0¾"
3'6½"
4'0"
4'8"
3'8½"

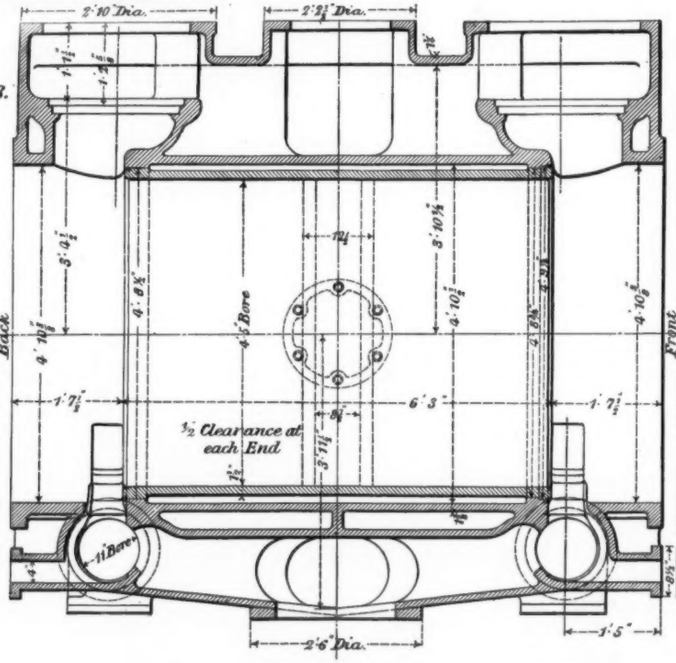


Fig. 13.
2'10" Dia.
2'2½" Dia.
4'5" Bore
6'3"
½ Clearance at each End
2'6" Dia.
1'5"
Back
Front

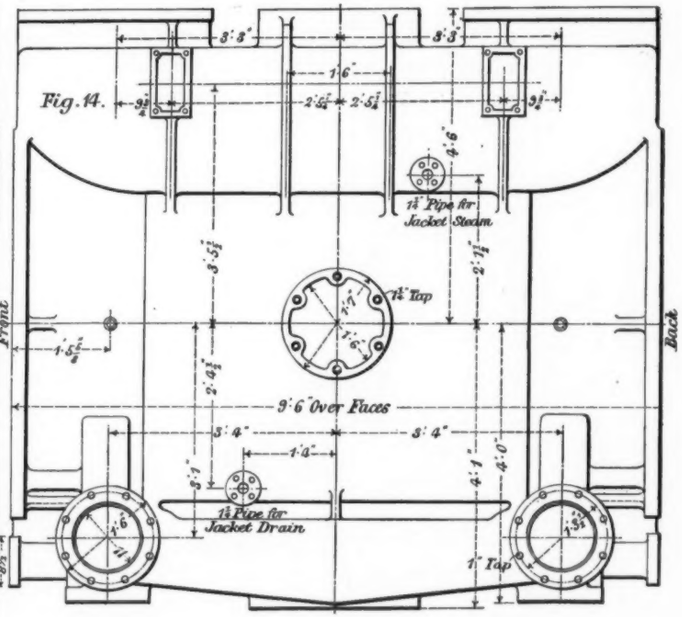


Fig. 14.
3'3"
1'6"
2'5½"
1½" Pipe for Jacket Steam
1½" Top
9'6" Over Faces
3'4"
1½ Pipe for Jacket Drain
1" Top
Back

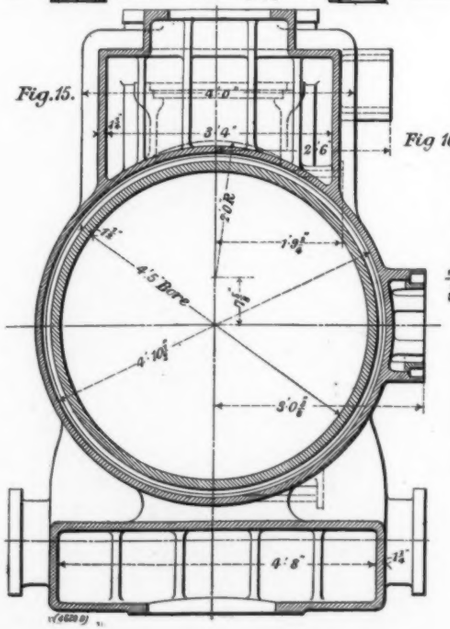


Fig. 15.
4'0"
3'4"
2'6"
4'5" Bore
4'8"

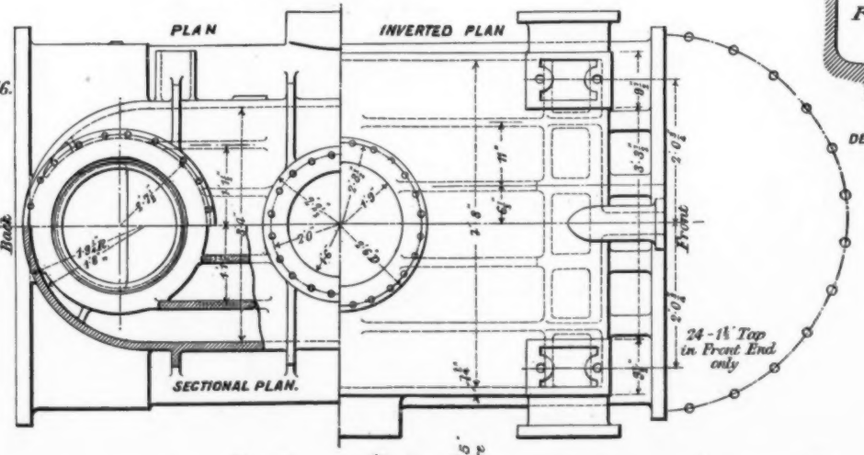


Fig 16.
PLAN
INVERTED PLAN
SECTIONAL PLAN.
24-1" Top in Front End only
Back
Front

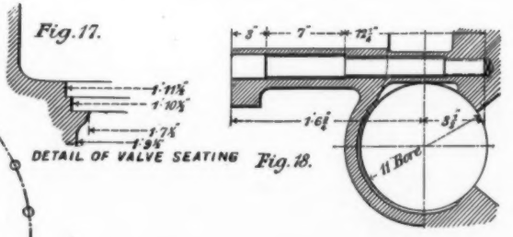


Fig. 17.
DETAIL OF VALVE SEATING
Fig. 18.
11" Bore

Jacket Steam
Jacket Drain
Indicator
SOUTH PIT WINDER B
Fig. 20.
KEY PLANS
Indicator
NORTH PIT WINDER A

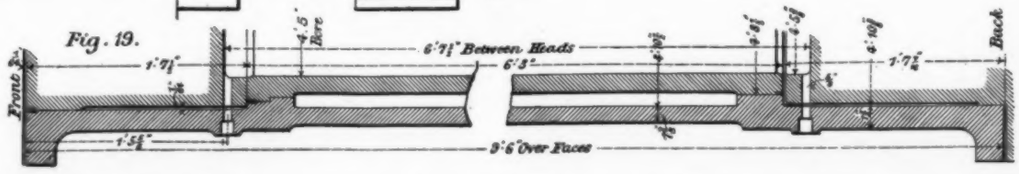


Fig. 19.
6'7½" Between Heads
6'3"
5'6" Over Faces
Front
Back

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Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

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We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

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TELEPHONE NUMBERS—3663 and 8598 GERRARD.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper, and of the consequent shortage of supplies, readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk. Owing to the scarcity of paper it will be impossible in future fully to provide for a chance demand for this Journal.

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NOTICES OF MEETINGS.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.—Saturday, April 8, in the Wood Memorial Hall, Newcastle-on-Tyne, at 2 p.m. The following papers will be open for discussion: "Modern American Coal-Mining Methods, with Some Comparisons," by Mr. Samuel Dean. "The Hirsch Portable Electric Lamp," by Mr. Hiram H. Hirsch. "The Logic of Trams," by Mr. John Gibson. The following paper will be read or taken as read: "The Influence of Incombustible Substances on Coal-Dust Explosions," by Mr. A. S. Blatchford, M.Sc.

THE ROYAL SOCIETY OF ARTS.—Monday, April 10, at 4.30 p.m. Fothergill lecture. "Surveying: Past and Present," by Mr. E. A. Reeves, F.R.A.S., F.R.G.S., Map Curator and Instructor in Surveying to the Royal Geographical Society (Lecture III.). Tuesday, April 11, at 4.30 p.m. Colonial Section.—"The Forest Resources of Newfoundland," by Sir Daniel Morris, K.C.M.G., M.A., D.C.L., F.L.S. The Right Hon. Sir William MacGregor, G.C.M.G., C.B., will preside.

THE SURVEYORS' INSTITUTION.—Monday, April 10, when a paper entitled "The Principles of Town Planning" will be read by Mr. W. R. Davidge, Fellow. The chair will be taken at 5 o'clock instead of 8 o'clock.

THE INSTITUTION OF AUTOMOBILE ENGINEERS.—Wednesday, April 12, at the Surveyors' Institution, 12, Great George-street, Westminster, S.W., at 8 p.m. Major B. W. Shilson, I.M.T., A.S.C., will read a paper entitled "From Engine to Axle."

THE ASSOCIATION OF ENGINEERS-IN-CHARGE.—Wednesday, April 12, at the St. Bride's Institute, Fleet-street, E.C., at 8 p.m. A lecture (illustrated by lantern slides) will be given by Mr. Gerald Stoney, F.R.S., M. Inst. C.E., on "Steam Turbines."

THE LIVERPOOL ENGINEERING SOCIETY.—Wednesday, April 12, at 8 p.m., at the Royal Institution, Colquitt-street, when a paper will be read by Mr. G. K. Paton, A.M.I.E.E., entitled "Electric Power in Slate Quarries."

THE INSTITUTION OF NAVAL ARCHITECTS.—Wednesday, April 12, and Thursday, April 13, in the Hall of the Royal Society of Arts, John-street, Adelphi. Wednesday, April 12, at 11 o'clock. Annual Report of the Council, election of President (The Right Hon. the Earl of Durham, K.G., G.C.V.O., P.C.) and Council, presentation of the Institution Gold Medal and Premium, and address by the President. The following papers will then be read and discussed: "On the Work of the Load-Line Committee," by Sir Philip Watts, K.C.B., F.R.S., LL.D., D.Sc., Honorary Vice-President; "Some Questions in Connection with the Work of the Load-Line Committee," by Mr. W. S. Abell, Member of Council. Afternoon meeting at 3 o'clock:—"The Laws of Skin Friction of a Fluid in Stream-Line and in Turbulent Motion Along a Solid of Great Length," by Mr. Charles H. Lees, D.Sc., F.R.S.; "Skin Friction Resistance of Ships and our Useful Knowledge of the Subject," by Mr. G. S. Baker, R.C.N.C. (ret.), Member; "Experiments to Determine the Resistance of Bilge-Keels to Rolling," by Professor T. B. Abell, Member; "An Experimental Tank Reproducing Wave Motion," by Colonel G. Russo, R.I.N., Member. Evening meeting at 7.30 o'clock:—"A Brief Summary of the Present Position of the Marine Diesel Engine and its Possibilities," by Engineer-Lieutenant W. P. Sillince, R.N. (ret.), Member; "On the Co-Ordination of Propeller Results," by Mr. J. Denholm Young, Member; "Note on Maximum Propulsive Efficiency of Screw-Propellers," by Mr. T. C. Tobin, Member. Thursday, April 13, at 11 o'clock:—"Sub-Division of Merchant Vessels: Reports of the Bulkhead Committee, 1912-1915," by Sir Archibald Denny, Bart., LL.D., Vice-President; "Strength of Water-Tight Bulkheads," by Mr. J. Foster King, Member of Council; "Some Effects of the Bulkhead Committee's Reports in Practice," by Mr. A. T. Wall, Associate-Member. Afternoon meeting at 3 o'clock:—"Notes from a Collision Case," by Mr. John Reid, Member; "Shipyard Cranes of the Rotterdam Dockyard Company," by Mr. M. G. de Gelder, Member.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Thursday, April 13, at 8 p.m. Discussion on: "The Present Position of Electricity Supply in the United Kingdom; and the Steps to be Taken to Improve and Strengthen it."

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Friday, April 14, at 5.30 p.m. An address will be delivered by Professor Sir J. J. Thomson, O.M., LL.D., D.Sc., Pres. R.S. The subject is: "The Genesis and Absorption of X-Rays." Afternoon lectures next week at 3 o'clock. Tuesday, April 11: Professor F. Keeble, M.A., Sc.D., F.R.S., Director, Royal Horticultural Society's Gardens, Wisley, on "Modern Horticulture: Old and New Methods of Forcing (the Breaking of Rhythm)" (Lecture III.). Thursday, April 13. Dr. W. H. Hadow, M.A., Hon. D.Mus., Principal, Armstrong College, Newcastle, on "English Music in the Tudor Period; Songs and Instrumental Pieces" (Lecture III.). Saturday, April 15. Professor Sir J. J. Thomson, O.M., LL.D., D.Sc., Pres. R.S., Professor of Natural Philosophy, Royal Institution, on "Radiations from Atoms and Electrons" (Lecture VI.).

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, April 14, at 6 p.m., at the Institution of Civil Engineers, Great George-street, Westminster. Subject of paper: "Theory and Practice in the Filtration of Water," by Mr. Walter Clemence, Member.

ENGINEERING.

FRIDAY, APRIL 7, 1916.

CENTRALISATION IN MILITARY AERONAUTICS.

THE creation of a Ministry of Air is a matter which is being pushed with much enthusiasm in certain quarters, and which enjoys the great advantage of the support of Lord Sydenham, whose judgment rightly carries great weight. That sooner or later such an office must be created is certain, for the extension of warfare to the atmosphere creates a condition of peril to us greater than has existed since the Dutch sailed up the Medway. We often congratulate ourselves on the "silver streak" which separates us from the Continent, as if that alone rendered us safe from attack. We forget that the entire width of the Atlantic did not save Mexico from the Spaniards and that the combined Atlantic and Indian Oceans did not keep us out of Hindustan. Our safety has hitherto been secured by the command of the sea, and in the future it will depend on our holding command of the air, for he who is supreme in the air will also be supreme on the water, at least as far as the "narrow seas" are concerned. It is therefore necessary that every possible step should be taken to fortify our position, and that the problem should be committed to the strongest hands that can be found.

The first—the chief—business of a Minister of Air will be to formulate a plan of air strategy and to carry it into effect. He must have the scientific imagination which sees the needs of the future, and the firm will to insist on the adequate means to meet them. We hear, however, very little about this. People clamour for more aeroplanes, more airships, and more anti-aircraft guns, and for more powerful instruments of all three types, and demand a Ministry of Air to supply them. Surely something less than a new department, with its Head in the Cabinet, could see to the fulfilment of such needs. That a centralisation of authority is urgent is well known to manufacturers who work for the aircraft departments of the Army and Navy, and are worried by contradictory requirements, necessitating double sets of gauges, taps, and jigs. A Board of Control, however, could do all that is needed. But, at the same time, whether there is a Minister of Air or a Board of Control, it is of vital importance that they should not seek to gather all initiative into their own hands, and thus stifle the inventive power of the country. Lord Sydenham wrote that "the advantages of entrusting construction, experiment and *matériel* generally to one body are obvious." If he had said the "control of construction, experiment and *matériel*," he would have been on safer ground, as, indeed, he seems to have felt by his saying that the precedent of the old Board of Ordnance was against the success of the proposal. The objection to the scheme of committing the entire design and manufacture of our aircraft to an official department is, however, not based on this single precedent only, but is founded on a knowledge of the inherent character of official human nature.

That some waste might be avoided by keeping experimental researches under the control of a single Board is possible, since no doubt there are frequent cases in which exactly the same ground is covered independently by experimenters with practically identical results. This is, however, by no means invariably true. In matters of research the man counts for more than the material and appliances placed at his disposal, and because a particular field has been traversed without result in one well-equipped laboratory, it may, nevertheless, not prove equally barren to a second independent investigator. Even in the case of purely scientific experiments extraordinarily discrepant results are at times obtained in different laboratories. In these cases, moreover, every care is, or should be, taken to eliminate disturbing factors, so as to test one thing at a time. This course is, however, as seldom practicable in the complex problems to be dealt with in practical aeronautics as it is in other departments of engineering. A noteworthy example is afforded by the numerous independent observations that were necessary to establish the true law by which the wind pressure on a plane varies with the angle of inclination. Even Langley failed to realise the significance of the curious instability of conditions which exist with inclinations of 30 deg. or so, and, like other investigators, tried to represent his results by a smooth curve covering all angles from 0 deg. to 90 deg. This instance well shows how important it is that several entirely independent centres of thought shall be at work, though there would be undeniable advantages in a Central Board which collated and distributed information from and to these independent nuclei, and at the same time stimulated further research.

The best results in design and experiment can only be achieved when there are several independent centres of thought in active competition with each other. A Central Board for the exchange and collation of results might, however, as we have said, be very useful in many cases; but where questions of design are entrusted wholly to a single department or board, matters are bound to get into a groove. Grooves are easy to run in, and to get out of them means the raising of the centre of gravity of the whole organisation over the ridge of the furrow—a Herculanean feat which is hardly to be expected from the average-salaried official, who has nothing much to gain if the upheaval proves beneficial, and may suffer severely in the contrary case.

On the authority of a former high official in the Trigonometric Survey Department, we are able to

give a highly instructive instance of this grooviness. He states that the India Office refused to adopt a very important improvement in their tide-predicting machine, because they had "organised" the process of computing and tabulating results. With the machine as originally supplied the reduction of the observations necessitated the repeated copying and recopying of long series of observations. A simple improvement made this laborious clerical work unnecessary, and would have permitted of a large reduction in the staff employed. Such a change would, however, have upset the "organisation" adopted by the central authority, and it was, our informant states, rejected accordingly.

Every Board tends to get filled, sooner or later, with "safe" conservative men, who, as the years pass, cannot always realise that some of their juniors in position and years might with advantage be given greater responsibility and initiative. This remark applies equally to Government offices and to private undertakings. In the latter case, however, salvation is found in the fact that a smart junior gets known to other firms, who may provide him with fuller opportunities. Again, all Government departments, and many commercial men, appear to distrust skilled technical advice. The very fact that a man knows something of Nature is held to preclude a knowledge of men. As one consequence we see that the Government scheme for British dyes deprived the technical experts of all control over policy, a condition which has proved fatal to more than one British firm of chemical manufacturers in the past. Dr. Baekeland, Perkin Medallist and inventor of Bakelite, confirms Professor Armstrong on the unwisdom of this policy. He insists on the absolute necessity of having chemists on the Board of every progressive chemical works. To merely employ able chemists is not enough. The successors to Messrs. Simpson, Maule and Nicholson did this, but they refused to take up the "blue" discovered by Professor Meldola, which afterwards founded the fortunes of one German firm, or to patent the pioneering discoveries of his successor, Professor Greene, which went accordingly to the profit of other Teutons.

In short, as Lord Sydenham has well said on another occasion, the type of organisation stereotyped in Government departments, and not unknown elsewhere, involves the man who knows all about a subject having to defer to one who knows less, and the latter to a still higher official who knows nothing whatever concerning the point at issue.

Any attempt to centralise design and experiment, and to discourage independent work, will necessarily imply restrictions on the initiative of many able men. This view is strongly supported in Dr. Beilby's recent presidential address to the Institute of Metals, in which the speaker emphasised the difficulty of restraining central organisations from hampering and hindering the fundamentally important work of our pioneers. A Central Board operating with mere salaried officials may, no doubt, conduct routine researches accurately and ably. It is of interest to note, however, that the high-explosive shell originated with M. Turpin, and the automatic machine-gun with Sir Hiram Maxim, and not with the central naval or military authorities of any nation. No student of human nature will doubt but that history will repeat itself, as in the past, and that it is useless to look to any central organisation for important new departures in either science or industry.

The true function of a Central Board would seem to be the collection and collation of facts, their transmission to those interested, and the preparation of general specifications, which so far as practicable should specify ends, rather than means. Of course, this latter proviso is somewhat of a counsel of perfection, and must be limited by considerations of interchangeability and standardisation; but these two gods, which necessarily occupy a high position in the official Pantheon, must by no means be elevated to the supreme seat in Olympus. The policy here advocated is, it will be seen, very much that which has been followed for many years past by the bridge-building departments of the American railways. These departments have issued general specifications, but have commonly left to the builders the preparation of the actual designs for such structures as they required. No one will question that on the whole the art of bridge construction in general has benefited very greatly in consequence. Certain mistakes, of course, were made, and as time went on, and experience accumulated, additional clauses, barring details and material found unsatisfactory in practice, have had to be added. Failures also have occurred, which would have been avoided had the beaten track of prior experience been more closely followed, but the ultimate result has been a very great reduction in the cost of every kind of structural steelwork.

None of our arguments is directed, however, against the creation of a Ministry of Air to deal with the broad aspects of the case. We do not think it is possible to give too much prominence to the subject of aerial warfare. It is in consequence of our neglect in the past that so much of our attention has now to be directed to air attack and defence. If we had had statesmen able and willing to read the writing on the wall, we should now be devoting ourselves to air attack, and instead of groping our way through darkened streets to beshuttered homes, we should feel as secure from German bombs as we do from German army invasion. Until Britain has the largest and most efficient air fleet in the world it cannot again be considered inviolable.

RADIATIONS FROM ATOMS AND ELECTRONS.

ON Saturday afternoon last Sir J. J. Thomson, O.M., P.R.S., delivered at the Royal Institution the fourth lecture of his course on the above subject.

In opening his discourse, Professor Thomson said that he wished to consider on that occasion a very important point in connection with radiation from luminous bodies, which, perhaps, might be illustrated best by taking a definite case. Suppose an atom or a molecule of a gas to be exposed to agencies of a violence sufficient to make it luminous. The point in question was, would any disturbance whatever, if of the appropriate type, produce some luminosity, or must the intensity of the disturbance exceed a limiting value before any light at all was given out. This matter was very much to the front nowadays in connection with the quantum theory, according to which the energy in the light of any wave-length was made up of definite units. It should therefore be as impossible to excite this light with a supply of energy equal to less than one of these units as it would be to obtain a mass of any element less than one atom in amount. Two views, in short, were possible as to the manner in which luminosity was produced. It might, in the first place, be supposed that the vibrator, responsible for the emission, had the characteristics of a violin string, which the least disturbance would cause to give forth some sound; on the other hand, the vibrator might resemble a bell with a heavy pendulum or clapper, in which case no sound was emitted unless the disturbance received was enough to make the clapper strike the side. If the first analogy held, the light-giving particle would respond to the smallest possible disturbance; but if the second assumption were the correct one, there would be no light emission unless the disturbance received exceeded some definite limiting value.

Indications as to which of these classes the atoms of luminous bodies belonged were first obtained from the comparative study of flame spectra, arc spectra, and spark spectra. In the flame spectrum of a given element certain lines could be observed, but others were absent. In the arc spectrum further lines appeared; whilst in the spark spectrum we got lines which were present neither in the flame nor in the arc spectrum. This observation suggested that certain lines required, to bring them out, the supply of a definite amount of energy, or at any rate of a disturbance of a definite amount. Some lines were not to be seen in the flame, and others not even in the arc, so that it looked as if the missing lines came in only when the violence of the disturbance responsible was in excess of a certain definite value.

The conditions in which flame, arc, and spark spectra were developed were, however, not suitable for giving a perfectly definite answer to the problem set. Flames, for example, were gases, and owing to the law by which the molecular velocities were distributed almost every intensity of energy was represented in them. A certain small proportion of these molecules were, in fact, endowed with very large amounts of energy. Matters were still less definite in the case of arc and spark spectra. The observations quoted gave, therefore, no very decisive response to the question at issue.

During the last few years, however, experiments had been made in conditions very much more precise, and physicists had in consequence been brought to the conclusion that in some cases, at any rate, a definite and determinate amount of energy was necessary for the production of light. Within these last few years spectra of the simplest possible type had been discovered, each consisting of only one line. The conditions in which the light emission was restricted to this had first been realised by Franck and Hertz. In the method used by them the luminosity was not excited by temperature, as in flames, or by a discharge, as in the case of the arc and spark, but the vapour studied was bombarded by cathode rays. These rays were produced in a definite field of force, so that all had the same speed, and this speed was, moreover, determinate. The rays were derived from a Wehnelt cathode, which consisted of a piece of platinum foil maintained at a red heat, and carrying at one point a speck of oxide of barium. In such conditions this oxide liberated negative particles in enormous quantity, and these particles could be given any velocity desired, by establishing an appropriate potential difference between the platinum foil and the corresponding anode. He could not, the lecturer proceeded, repeat this experiment in the lecture-room in its original form, but by the modification of the apparatus represented diagrammatically in Fig. 1 he was able to show that the colour of the light excited by the bombardment varied with the speed of the rays.

The speck of barium oxide on the platinum strip was represented by A. The particles were shot out from A, all with the same velocity. An inclined plate B was placed in the path of the rays. So long as this plate was uncharged the negative particles emitted from A proceeded in straight lines and with uniform velocity. As these particles passed through the gas they knocked against the molecules and made them luminous, and the character of the spectrum thus produced could be determined in the usual way. By charging the plate B negatively the particles were repelled. As a consequence they were slowed down and their paths bent round into parabolas, as indicated. At the points of nearest approach of its path to the plate the particle would accordingly be moving less rapidly than elsewhere, and, the lecturer pointed out, the colour of the light excited in this neighbourhood was reddish, whilst where the speed was high it was blue. This experiment therefore showed, the lecturer said, that the colour of the light emitted depended on the speed of the negative particles by which it was excited.

Fig. 1.

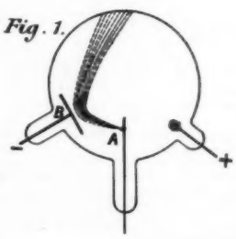
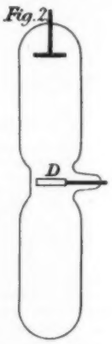


Fig. 2.



The apparatus used by Franck and Hertz was, he proceeded, essentially the same as the foregoing, but with the plate B omitted, so that the speed of the particles depended solely on the potential of the platinum foil, and was constant throughout the apparatus. They filled their apparatus with vapour of mercury, and observed the appearance of the spectrum as the potential of the platinum strip was step by step increased. They found that so long as the effective potential difference was less than some 5 volts, the light emitted yielded merely an ill-defined continuous spectrum. So soon, however, as this potential reached 4.9 volts a single bright line made its appearance, having a wave-length of 2536 Angström units. Moreover, the line thus excited was the first member of a special series in the spectrum of mercury. A further peculiarity was that the energy of each of the negative particles constituting the rays was, at the critical moment at

which this line appeared, practically exactly that indicated as necessary by the quantum theory. According to this theory, the energy required to excite light of a particular wave-length was equal to $6.6 \times 10^{-27} \times$ frequency, where the "frequency" denoted the number of vibrations per second. Substituting in this formula the frequency corresponding to a wave-length of 2536 Angström units we got, he said, 4.5 volts as the potential difference through which a negative particle must fall to acquire the above amount of energy. This result provided, therefore, a remarkable confirmation of the view that definite units of energy were required to produce light of any specified wave-length.

This single-line spectrum was the simplest known. If the potential difference were increased beyond 5 volts, then for a certain range the spectrum still consisted of this single line. Professor McLennan, of Toronto, had, however, discovered that when the potential reached 12.5 volts the spectrum suddenly became very complex, being, in short, the ordinary line spectrum of mercury. The most interesting point about this discovery lay in the fact that certain of the lines which then appeared lay on the red side of the original single line. According to the quantum hypothesis, these lines, being of longer wave-length than the original line, should require a smaller unit of energy to excite them. It would have been natural to expect, therefore, that these lines in the red would have made their appearance earlier than the single line first developed, which lay actually in the ultra-violet. As a matter of fact, however, experiment showed that to obtain these red and yellow lines of mercury it was necessary to provide more than double the energy which sufficed to bring out the orginal single-line spectrum. This point was of great importance in connection with the mechanism of radiation. It appeared, as stated, that the red line was not produced by the supply of its "energy equivalent" to the radiating atom, but that a much greater quantity was necessary. It seemed, therefore, as if it were necessary to alter the atom in some way before the red line could be made to appear. In fact, these red lines were not excited until the energy supply was three or four times that necessary for the original single line. The long waves subsequently emitted formed, in short, part of a system which could not be excited until the energy supply was enough for the blue components of the system, or, at any rate, until the constitution of the atom had in some way been altered.

In addition to mercury, McLennan had also worked with vapours of zinc, cadmium, and magnesium. In all cases he had obtained these single-line spectra, the wave-lengths being as follow :—

	λ.
Mercury	2536 Angström units.
Zinc	3075 " "
Cadmium	3260 " "
Magnesium	2852 " "

All these elements, Sir Joseph proceeded, could be made to yield single-line spectra, and what was of the greatest interest was that in each case this single line was the first member of the same spectral series of the metal. This fact supplied a remarkable confirmation of the view that the series into which spectroscopists had been led to divide spectral lines had really some physical meaning.

So far as the speaker knew, single-line spectra had not yet been obtained with other elements than the four named. In particular nothing of the kind had been noted with such gases as hydrogen, chlorine, or oxygen, but the discovery had undoubtedly opened up a very interesting field. It was not merely the existence of this single-line spectrum that was of interest, but also the stage at which it appeared. The experiments permitted the hope that in this way the stages at which certain types of spectra appeared might be determined. This would establish the connection between different lines by sorting them out into different series. In fact, an important means of classifying some of the complicated spectra would be obtained if it could be established that certain lines made their appearance at definite stages. So far, however, the method had only been applied to the vapours named, but it could probably, the speaker thought, be extended to other elements.

Another way of showing, at least qualitatively, the connection between energy supply and luminosity was, he proceeded, to insert an exhausted bulb, containing a trace of gas, near a coil traversed by a rapidly alternating current. If the bulb were placed close to the coil it experienced a strong field, whilst if withdrawn a little the field was weakened. In exhibiting this experiment the lecturer pointed out that the character of the light in the bulb varied abruptly as its distance from the coil was altered. If the bulb were more than a certain distance away, the light given out was diffused throughout the whole bulb; but on the critical limit being passed a brilliant ring of light sprang into being inside the bulb, which disappeared just as abruptly as the distance was again increased. The ring was in all cases either exceedingly bright or entirely absent. The spectrum of the light from such a bulb also changed, the lecturer stated, abruptly with the appearance and disappearance of the ring. Hydrogen, for example, had two spectra—viz., its ordinary line spectrum, and a second exceedingly complicated spectrum, with almost innumerable lines, especially in the red and yellow. With a bulb filled with hydrogen, this latter spectrum was, he said, that observed until the ring appeared. At this instant the line spectrum of hydogen sprang out with great brilliance, all the lines being present and all bright.

This observation afforded, he said, further testimony in favour of the view that these lines only came in when the energy exceeded a certain amount. The same general effect was obtained with other gases, but each had its characteristic strength of field at which the ring appeared inside the bulb. The first stage came in at one definite value, and the second at another definite value. These values were characteristic of the gas under observation, being alike for no two gases. To the abrupt change in the appearance of the bulb from the general glow to the bright ring corresponded, he proceeded, a similar change in the strength of the induced current inside the bulb. As soon as the ring appeared the energy absorbed became as great as if the bulb had been filled with the best conducting mixture of sulphuric acid and water. The energy absorbed prior to the appearance of this ring was by no means on the same scale, and the bulb could be run under these conditions for hours without getting hot.

Another method of showing the discontinuous way in which luminosity arose was, Professor Thomson said, to bombard gases with positive rays; that was to say, with atoms of the gas itself, instead of with the cathode rays. The spectra obtained with the two kinds of bombardment differed remarkably, even when the energy of the particles was the same in both cases. With the same energy the positive particles, being much the heavier, moved more slowly than the negative particles.

The difference in the character of the light in the two cases was illustrated by means of a vacuum tube containing helium, and of the form indicated diagrammatically in Fig. 2. The electrode at D was perforated, so that positive rays passed down it to the helium below, causing it to shine with a red light, whilst the cathode rays in the upper part of the tube produced a bluish light. In a variant of this experiment the helium was contained in a bulb fitted with opposing electrodes, each in the shape of a triangular plate, the two being spaced parallel to each other and a short distance apart. On passing the discharge positive rays streamed out from the corners of the triangular space, giving pencils of red light, whilst the negative particles, which came out at the mid-points of the sides, produced pencils of bluish light. In this case both kinds of particles had, the lecturer said, the same energy, but the spectra excited by them were entirely different. In another experiment the lecturer bombarded lithium chloride, at first with negative particles and then with positive rays. The chloride gave out a bluish light in the former case, whilst with the positive rays the light was red. It was noteworthy in this connection, the lecturer said, that the effect was much more marked with compounds than with the pure elements. With the latter very little was to be seen. Thus when a pool of the liquid alloy of sodium potassium was bombarded, the specks of oxide which contaminated the surface shone with the characteristic sodium light like stars in a dark sky; the intervening clean surface remained, however, perfectly black.

In all these cases, in which luminosity was produced by bombardment, it was necessary, Sir Joseph said, that the particles should travel above a certain speed. Hence the light always made its appearance more or less abruptly when the potential under which the rays travelled rose beyond a certain limit. The value of this limit had been measured for a good many substances, and in general it was found that a potential difference of 600 to 700 volts was necessary to make a salt yield the characteristic lines of an element. To make lithium chloride luminous, for example, 700 to 800 volts were required. All these experiments concurred in indicating that to excite luminosity it was necessary to communicate definite amounts of energy, and the luminosity was therefore not proportional to the disturbance producing it, but came in discontinuously when the energy of the disturbance exceeded a certain limiting value.

The next point which arose was to determine the nature of the luminous particles. Were they atoms or molecules, or something still more complex, when the characteristic spectral lines were emitted? The positive rays provided a means by which this question could be decided. If they were sent through hydrogen, for example, the particles of hydrogen which gave out the light were moving at a speed which was not insignificant as compared with that of light. By Doppler's principle the spectrum given out by a moving particle was not the same as that of the same particle at rest, the lines being all displaced, towards the violet if the particle were approaching the observer, and towards the red in the contrary case. If this displacement were measured, the velocity of the particle emitting the light could be determined. On examining the positive rays, Stark had found that all the lines given out were displaced, and by an amount capable of accurate measurement, so that the velocity of the light-giving particles could accordingly be calculated. As the atoms and molecules of hydrogen were moving at different speeds, it was thus possible to determine from which of the two the light was derived.

GASOLINE FROM NATURAL GAS.

NATURAL gas is of no importance in this country, and is not ever likely to be; it is, however, of some promise in certain of the Colonies. The United States produced, in 1914, 591,866,733,000 cub. ft. of natural gas, valued at 94,115,624 dols. Though decreasing in some States, notably in Pennsylvania, the gas output was increasing in others. The figures would be much higher if the waste of gas could more easily be prevented. Gas and oil frequently occur together, though not necessarily so, and probably have the same origin then. When the same sand stratum contains both gas and oil, the prospectors may strike either gas or oil, or both together, or neither. When oil and gas rush out together, the oil can frequently not be utilised without wasting the gas; for the gas cannot be stored like the oil. In this way oil-fields have been depleted of their gas, and the waste has other serious consequences. The gas pressure down below helps to force up the oil, and retards the encroachment of water, which, gaining the upper hand, may cut off certain sections of the oil-producing area. Again, the expanding gas cools the oil, which leads to the formation of waxy sediments in the productive stratum and in the tubing, so that the flow of oil is obstructed. A large escape of gas in one part of a field may detrimentally reduce the gas pressure all over the field. In this way the Hogshooter pool in Oklahoma is believed to have been ruined by having its gas drained too rapidly; the initial "rock pressure" in these cells was 480 lb. per sq. in.; double that pressure has been registered in Clarion, Pennsylvania, at 2100 ft. depth.

Thus the escape of gas should be checked for several reasons. The first rush from a newly-drilled well can rarely be stopped, however, and some 10,000,000 cub. ft. of gas may be lost. That rush diminishes afterwards, and the gas usually finds its way to the atmosphere through the spacing between the casing of the well and the oil-tubing. This "casing-head gas" frequently contains enough of the gasoline constituents to warrant the erection of a plant for condensing the liquefiable gas. The gas coming up with the oil-flow may be collected for similar treatment by means of gas-traps, the oil entering a drum in which gas and oil separate. An elaborate gas-trap, due to E. Starke, was described in the *California Derrick* of September 10, 1914. In this trap the mixture of sand, oil, and gas, forced up the tubing, passes through a long drum —*i.e.*, a gas-pipe, 10 in. in diameter, 800 ft. long —to which "risers," separately controllable, are

attached at short intervals; as the gas is thus trapped at many points of the upper surface of the pipe, the gas rush is diminished; the oil and sand are allowed to separate in a settling-tank at the end of the pipe. The device is said to have proved capable of dealing with gas-gushers. Even when the oil-well is past its flowing stage, and oil-pumping is resorted to, gas may still be given off at the casing-head. In the early eighties, it will be remembered, the gas escaping from stand-pipes was simply burned in Pennsylvania to prevent it doing mischief, and the huge flames roared continuously all over the oil-fields. Then the gas was piped and burned in lamps and metallurgical furnaces, and Pittsburg, so far known as the dirtiest city of the Eastern States, became one of the cleanest.

The condensation of gasoline from natural gas has been investigated by the United States Bureau of Mines, and Bulletin 88, drawn up by G. A. Burrell, F. M. Seibert, and G. G. Oberfell, deals with this subject. The condensation is effected by means of cooling and compressing in one or more stages. The first commercial ventures of this kind date from 1904, and are credited to Fasenmeyer, of Titusville, and to Tompsett Brothers, of Tidioute. East of Mississippi 253 gasoline condensation plants were in operation by July, 1913, West Virginia and Pennsylvania having each 100 of these plants. In the former State, 1500 out of 14,000 producing oil-wells were utilised for gasoline production, from 1 to 100 wells, 15 or 20 wells on an average being connected to one plant; the total gasoline production from this source in 1913 amounted to 7,662,493 gallons. In Pennsylvania, about 1200 wells out of 56,000 were producing gasoline, mostly less than 500 gallons per day, and the total production of the year 1913 amounted to 3,680,096 gallons. In California 16 plants, of a total daily gas capacity of 25,000,000 cub. ft., gave about the same total gasoline yield of 3,460,747 gallons from 16,950 wells. Oklahoma had in May, 1913, 23 gasoline plants, supplied by 300 out of 25,000 oil-wells; by the end of 1913 forty plants were in operation, and the total gasoline production of the State was estimated at 6,462,968 gallons in that year. Altogether, 24,060,817 gallons of gasoline were condensed from natural gas in the United States in 1913—twice as many as in 1912—and they were valued at 2,488,443 dols. Thus the industry is decidedly on the increase in the United States, whilst in other countries little more than a beginning has been made. Not every natural gas is suitable, of course.

As regards the chemistry of natural gas, it is customary to distinguish "dry" and "wet gas;" but a sharp line cannot be drawn. Dry gas has not been in intimate contact with oil and has probably a different origin; it contains mainly, or only, methane as its combustible constituent, and hence is no good for gasoline condensation. The Hogshooter gas above mentioned is very dry. The Pittsburg gas, which passes through pipes at a very high velocity without leaving any "drip" to speak of, is also dry. Wet gas has been in contact with oil, and has taken up various products, principally of low boiling-points, just as air takes up water vapour. The amounts taken up and recovered on treatment depend upon the temperature and gas pressure or rock pressure below. The ordinary constituents of American natural gas are the paraffin hydrocarbons: methane, CH_4; ethane, C_2H_6; propane, C_3H_8; butane, C_4H_{10}; pentane, C_5H_{12}; hexane, C_6H_{14}; heptane, C_7H_{16}, &c. The boiling-points of these are in the same order: − 160, − 93, − 45, + 1, + 36.4, + 68.9, + 98.4 deg. Cent. In addition to these hydrocarbons, the gas may contain up to 31 per cent. of carbon dioxide and some nitrogen; of the latter, 97.9 per cent. was found in one case; hydrogen sulphide has also been observed, but carbon monoxide, hydrogen, and hydrocarbons of the olefin series are absent from American natural gas, nor is air a frequent constituent.

Of the paraffin hydrocarbons mentioned, methane, ethane, propane, and also butane have too low critical temperatures and too high critical pressures to occur in the liquid state in rock strata. Even if they did, their recovery by condensation would require too low temperatures and too high pressures to become profitable, especially when those hydrocarbons are only present in small percentages in fairly dry gases. Pittsburg gas, *e.g.*, contains 3 per cent. of propane and 1.3 per cent. of butane. Condensation is profitable for the higher members, and by "gasoline" the American trade understands the hydrocarbons pentane, hexane, heptane, &c., of which an oil may contain 30 per cent. Hence careful testing of a gas is required before any plant can be laid down. Tests of gravity and solubility (in various solvents and absorbents, alcohol, sperm oil, kerosene, &c., claroline oil being much used) and combustion tests do not suffice; the experts rely on portable condensation outfits, comprising compressors and cooling-coils. Plants hastily laid down have had to be abandoned for dearth of suitable gas.

We stated already that in the condensation plants the gas is cooled and compressed. In single-stage compressors a pressure of 110 lb. per sq. in. is rarely exceeded—though 150 lb. is also recommended—to avoid undue heating and diminution of the efficiency. In two-stage compressors 35 lb. is the average pressure for the first stage, during which the temperature of the gas may rise considerably; cooling is effected by passing the gas at that pressure through 2-in. pipes, 100 ft. long for every 100 cub. ft. of gas-flow per minute. In the second compressor, at 250 lb. or 350 lb. per sq. in., the temperature will rise to 480 deg. Fahr., and the still compressed gas is once more sent through 2-in. pipes, water-cooled, and then allowed to expand into the jacket of the last section of the pipe, the pressure being reduced to 30 lb. per sq. in. The temperature is said to fall to 39 deg. Fahr.; but the expansion has not always answered, and F. P. Petersen, in Oklahoma, prefers closed expansion against the piston of a power cylinder.

This latter rational method is also much used in California; but there, according to Laney, has been trouble from moisture in power cylinders, because the temperature may go down to − 60 deg. Fahr., although the gas is carefully dried and is cooled below the freezing-point of water before entering the cylinder. The final cooling is also effected by means of ammonia refrigerators. The condensed liquid will consist of butane, propane, hexane, &c.; some of these products, and also ethane and methane, are present, not owing to the pressure and temperature conditions, but because they are soluble in the already liquefied gas.

The condensed liquid is trapped in accumulators, from which the gas may be returned to the compressors, &c.; but little seems to be gained by this second treatment. The cooling-pipes are generally carried on poles in the open. Some plants comprise six 50-horse-power direct-driven compressors, and can deal with 2,500,000 cub. ft. of gas per 24 hours; most plants are much smaller. At Tidioute, already referred to, a very simple system is in use on a small scale. The producing wells tap the third sands, and the gas comes up under a reduced pressure of 20 in. of mercury, and is at once cooled and condensed. The cost of plant and working varies, of course. The Bulletin mentions one instance in which a return of 55 per cent. is realised. Air leakage into the oil through the rock strata or into the pipe system is very undesirable; but the authors of the Bulletin have found up to 40 per cent. of air in the compressor gas. On the other hand, escape of gas has caused disastrous explosions and fires.

From what we have said it will be clear that the term "condensed gas" would really be more correct for the liquid obtained from the natural gas than the indefinite term "gasoline." This trade term, however, has come into use, though it does not any more describe a product of definite composition than many others; petroleum ether, *e.g.*, consists essentially of pentanes and hexanes, naphtha of hexanes, heptanes and octanes, and benzine (in the United States) of octanes and nonanes. The (gasoline) condensate used to be submitted to "weathering" in order to lose, by evaporation, its most volatile constituents, so as to become safe for transport. This weathering was very wasteful, and at present all the condensate is blended with naphtha and then sold as gasoline.

NOTES.

Electrical Transference in Amalgams.

According to the electron theory, the electric conductivity of metals is chiefly due to the passage of electrons through the metal, the electrons being much more mobile than other carriers or particles which might take a certain part in conductivity. The influence of any such other carriers can hardly be studied in pure metals; it might be done in alloys or solutions of metals. Now metals were supposed to differ from metalloids among other features also by the fact that they were not as such soluble in any ordinary solvents like water—*i.e.*, without entering into chemical compounds — but soluble in one another (as amalgams and alloys). But C. A. Kraus showed a dozen years ago that certain liquids, like liquefied anhydrous ammonia, sulphur dioxide, &c., would really dissolve metals as metals. Thus sodium dissolved in liquid ammonia dissociates, according to Kraus, into positive sodium ions and negative electrons, and when a current is passed through the solution, the sodium travels with the positive current—*i.e.*, to the cathode. It appeared possible to Gilbert N. Lewis, who has been associated with Kraus in several researches, that a highly positive metal like sodium, when dissolved in the much less positive mercury (as amalgam), would conduct the current in the same way and that sodium would travel to the cathode in that case too. Investigating this problem in the University of California, together with Elliott Adams and Edith Lanman (Journal of the American Chemical Society, November, 1915, page 2656), he found to his surprise that there was indeed a (very slow) travel of the sodium, but to the anode, not to the cathode. The amalgams were prepared by electrolysis, and transferred into an evacuated vessel of the shape of an inverted Y, the vertical limb serving as receptacle for the amalgam, which, on opening a tap, flowed into the two oblique limbs; the latter contained the platinum electrodes. The amalgams used were very weak, containing only up to 4 milli-equivalents of sodium, and the analyses were hence very difficult. But electrolysis continued for several days by currents of up to 8 amperes produced a certain transport of sodium, and in other experiments of potassium, with the negative current, however, as stated. The authors find a clue to the explanation of this peculiarity in the fact observed by Bornemann and Müller in 1900, that the addition of sodium and potassium to mercury lowers the conductivity of mercury, instead of improving it, whilst lithium and caesium have the opposite effect. Lewis argues that this diminution of the conductivity by the addition of sodium is probably due to a diminution of the mobility of the electrons. He assumes that the sodium atoms form nuclei for large aggregates of mercury atoms in the amalgam, and that small regions of amalgam would be embedded in the mercury; an electron meeting one of these regions would then, by a kind of reflection or refraction, impel that region to travel towards the anode with the electron. The fact that potassium travelled twice as fast (the transfer being 3.6×10^{-6} equivalent per farad) as the sodium, as it should in analogy to its effect on the conductivity of mercury, would appear to support that argument; whether or not caesium and lithium would travel in the opposite direction has not been tried yet. But the whole argument does not look very convincing, and it is, perhaps, just as well it does not, though Lewis does not express himself in that sense; for the electron theory of the electric conductivity of metals has long been under a heavy cloud.

The Development of Technical High Schools in Germany.

In Germany the opening of the first technical school, which took place two years after the Savannah had made her first trip across the ocean, was speedily followed by the erection of technical schools in Karlsruhe, Munich, Dresden, Stuttgart, Hanover, and Darmstadt. The elevation to high schools in most cases took place in the sixties, but for some it did not occur until the seventies. The technical high schools at Zurich, Aachen, and Brunswick were the first to be constituted as high schools from the outset. The commencement of scientific research and experimenting at the technical high schools took the shape of material-testing institutions, which were started in a very modest way in Munich in the year 1868, in Berlin in 1871, in Zurich in 1879, and in Stuttgart in 1884, by degrees to grow into most important establishments. In a similar unpretentious manner, the machinery laboratories were commenced in Munich in 1875, in Stuttgart in 1886, in Darmstadt in 1895, and in Berlin in 1896. An electro-technical institute was formed in Darmstadt in the year 1883, in Berlin in 1884, in Dresden in 1886, and in Munich in 1888. The States have rendered very material

pecuniary support to the growth of the technical high schools, an assistance which is more pronounced in extraordinary, than in continuous, grants. In the period between 1888 and 1896 there were no special institutes or new important buildings erected. Then in 1896 the building of the machinery laboratory and extension of the Berlin Technical High School was commenced. The great increase in the size and scope of this latter high school took place in 1905, when the chemical institute was very materially enlarged, at the same time as the laboratories for water-motors, machine-tools, and internal-combustion engines were built, and the power-station of the high school materially extended. At about the same time the erection of new technical high schools commenced in Prussia. A grant of about 6,000,000 marks was voted for the building of the new technical high school in Danzic, and during the following five years 4,000,000 marks were voted for the first buildings of the technical high school in Breslau, and at the same time some 3,000,000 marks were expended upon the mining institute at Aachen, and 2,000,000 marks upon the chemical institute in Hanover. During the subsequent years the extra votes diminished materially, on account of the financial position of the country. At the Berlin Technical High School the students' fees defray about one-third of the aggregate expenses. The present annual expenditure of the Berlin High School is about 2,100,000 marks, of which 1,300,000 marks go to paying the professors and assistants, whilst 800,000 marks are absorbed by teaching material, the pay of officials, &c. The year 1900 seems to have formed a kind of turning-point in the history of the German technical high schools; from this year, which followed upon the centenary of the Berlin Technical High School, at which the Emperor, so to speak, entered the lists on behalf of these institutions, the outlay in all sections has steadily risen. The number of students at the Prussian technical high schools shows very considerable fluctuations, in harmony with the industrial position of the country, although this feature does not make itself equally promptly felt at the different technical high schools. Thus the number of students at the Danzic Technical High School rose steadily up to the year 1910, and has since then remained almost stationary. In Aachen the increase slowly went on until 1908, and since then there has been no marked variation in the number of the students. In Hanover the top was reached in the year 1903, and then a slow decrease in the number of students began to set in. The Berlin Technical High School, with a rapidly ascending curve, reached its zenith, as far as the number of students goes, in the year 1902, when the curve rose beyond 6000, in order, however, to begin its downward course at an almost equally rapid rate, the industrial depression of 1902 making itself almost immediately very materially felt. No doubt the opening of the Danzic and Breslau technical high schools deprived the Berlin High School of a fair number of students. In Berlin there are most students during the winter, whilst in Danzic the reverse is the case. Hanover and Aachen formerly had most students during the summer, but since 1902 this has changed.

LARGE NEW WIRELESS STATION IN NORWAY.—At Ooresäter, Norway, a large new wireless station is about to be erected, and the contract has been signed with the Telefunken Company, Berlin. The new station, which will have masts of 100 metres height, is intended for correspondence with the large European wireless stations. In addition, a smaller station will be erected for the benefit of shipping. The new wireless station will be after the same principles as the one at Nauen, near Berlin; it should be ready next autumn, and will cost about 22,000*l*.

THE UNITED STATES NAVY.—Rear-Admiral Taylor, Chief of the United States Bureau of Construction and Repair, has forwarded to the Naval Committee of the United States House of Representatives a statement to the effect that the current new naval building programme can be completed according to schedule if Congress will appropriate sufficient funds to enable the Government to compete with private shipbuilders who are offering bonuses for early delivery. The only obstacle in the way is a possible shortage of skilled workmen. Admiral Taylor states that there are ten building-slips in private yards which are capable of taking the largest war vessels. Of these, four are specially equipped for building battle-cruisers. Delay has taken place in commencing the construction of battleships Nos. 43 and 44, as Mr. Secretary Daniels is anxious to have the vessels built in naval yards.

THE LATE MR. HENRY MORGAN.

ONE more of that little band of distinguished naval architects who were responsible for the solution of the many problems associated with the transition first from wood to iron and later to steel, as a material for ship's hulls, and for determining the salient features which have since dominated warships of the line, has passed away in the person of Mr. Henry Morgan, who died at his residence at Clapham Common on the 3rd inst., in his eighty-third year. He was a contemporary of Reed, Barnaby, Barnes, and Crossland, and shared with them the work of design and construction of the earlier ships of all classes for the Navy, and although greater work has been done since all of these early workers relinquished their positions at the Admiralty in the 'nineties, the foundations which they laid in theory and practice must be recognised as of great influence on subsequent successes.

Born in 1834, Mr. Morgan came of a family of shipwrights; his father, Mr. George Morgan, was one of the old-time Inspectors of Shipwrights in His Majesty's dockyards, and in the absence of direct issue the family tradition is continued by two nephews, Messrs. John and G. M. Apsey, the responsible heads of the constructive departments at Portsmouth and Rosyth Dockyards respectively. Like Reed and Barnaby, Mr. Morgan served his apprenticeship in Sheerness Dockyard, and was selected for a special course at the original school at Portsmouth, where he continued from 1851 to 1854, when the school was disbanded. He was a draughtsman in 1854-5, was promoted acting inspector of shipwrights in the latter year, and five years later was given full rank. In 1864 he was further advanced to the responsible position of foreman of the yard, and in 1867 to assistant master shipwright. These were the days before the Royal Corps of Naval Constructors was formed, and it will be understood that under these designations Mr. Morgan was steadily advancing to the highest position in the naval architectural staff of the Admiralty.

The late Mr. Morgan proceeded to the Admiralty in 1869, under Sir (then Mr.) Edward J. Reed, who soon after retired, being succeeded as head of the Constructive Department by Sir (then Mr.) Nathaniel Barnaby. Until 1872 there was a "Council of Construction," of which Reed, Barnaby, Mr. F. K. Barnes, and Mr. J. B. Crossland, as well as Mr. Morgan, were members, the last-named acting as professional secretary. When this committee was dissolved in 1872, Barnaby becoming in name, as well as in reality, Chief Naval Architect, and three years later "Director of Naval Construction," Mr. Morgan continued his assistant, with the title of "Constructor," and from 1875 Chief Constructor—terms of higher significance than the same designations convey to-day. Mr. Morgan, too, continued to act as secretary to such meetings as were held in connection with design. After Barnaby retired Mr. Morgan was, until 1892, Sir William White's assistant, and thus for about twenty-five years he was actively engaged on the design of warships, including also the period when Lord George Hamilton's Naval Defence Act fleet was built. His retirement in 1889, at the early age of fifty-nine years, was due to failing health.

Mention may be made of some of the ships with which his name was more particularly associated. The Trafalgar and Nile were among the battleships. He also designed the Curlew and Landrail—the first vessel built of steel at Devonport Dockyard. He was responsible, too, for the design of the Rattlesnake, the first of the vessels leading up to our present very much larger torpedo-boat destroyers and then a famous vessel. She was built by Messrs. Laird Brothers, of Birkenhead, who had had great experience in building light scantling blockade-runners of great speed. Mr. Morgan also assisted in designing the ships of the "Mersey" class—viz., Mersey, Severn, Thames, and Forth—which were the Admiralty rivals of the then famous Elswick cruiser Esmeralda.

Although Mr. Morgan was not one of the sixteen who founded the Institution of Naval Architects, he joined, in 1860, immediately after the preliminary meetings, and was the oldest surviving member. From 1871, when he was elected a Member of Council, until the end he devoted much of his ability—although always unobtrusively—for the advancement of the Institution, recognising its great usefulness in connection with the progress of naval architecture. He became a vice-president in 1888, was hon. treasurer from 1891 to 1905, when he was elected an hon. vice-president. In 1894 he became also a trustee. He occasionally took part in the discussions in the earlier years, but his uncertain health, from the nineties onwards, precluded him from taking much part in public life. He was a brilliant naval architect and a skilful controversialist, and his participation in the discussions was always suggestive and welcome. He had most engaging manners, and, alike for his personal as for his professional qualities, will live in the memory of many friends.

INDUSTRIAL NOTES.

SINCE our note on page 310 *ante*, dealing with the situation on the Clyde, the men on strike have gradually gone back to work, and have decided, we understand, to hand over their grievances to the trade unions for settlement.

The English coal-miners who had applied for a 5 per cent. advance in wages have received satisfaction. Last Friday, Lord Coleridge, independent chairman of the English Coal Conciliation Board, telegraphed to Mr. Thomas Ashton, general secretary of the Miners' Federation of Great Britain, and secretary of the men's side of the board, intimating that he had decided in favour of the men's application.

This decision affects 350,000 miners in England. The application was originally made to the Coal Conciliation Board, but, that body being unable to agree, the matter was referred to the independent chairman, Lord Coleridge, who has decided that the selling price of coal justified an advance of wages. The present rate of wages is now 80 per cent. above the 1888 basis, and wages are the highest ever reached by the miners of Great Britain.

The bi-monthly ascertainment of selling prices for iron was issued last Friday. It shows that the average net rate rose during January and February from 11*l*. 4s. 4.83d. to 12*l*. 3s. 11.80d. The output was lower by about 200 tons, the production of the seventeen firms on whose experience the sliding-scale is regulated amounting to 30,333 tons. In consequence, a further advance of 10 per cent. in wages took place last Monday in the industrial districts covered by the Midland Iron and Steel Wages Board, the advance to remain in force during April and May. Puddlers' wages will be at the rate of 15s. per ton, as against 9s. 6d. at the beginning of the war.

Owing to recruiting, labour at the furnaces is far from adequate.

The following is the statement taken from the accountants' report of the different classes of iron sold and the average net selling price:—

January-February, 1916.

Description.	Weight.	Per Cent. of Totals.	Average Net Price.
	tons ct. qr. lb.		£ s. d.
Bars	21,050 5 2 16	69.40	11 17 11.78
Angles and tees	1,274 5 0 6	4.20	12 10 7.71
Plates and sheets ..	527 12 2 11	1.74	14 7 1.23
Hoops, strips, and miscellaneous	7,481 3 3 27	24.66	12 16 8.34
	30,333 7 1 4	100.00	12 3 11.80

November-December, 1915.

Bars	21,741 1 2 6	71.20	11 0 5.26
Angles and tees	691 16 0 21	2.27	11 9 10.96
Plates and sheets ..	677 18 2 16	2.22	12 10 7.63
Hoops, strips, and miscellaneous	7,421 19 1 17	24.31	11 13 1.37
	30,532 15 3 4	100.00	11 4 4.83

The accountants to the Board of Conciliation and Arbitration for the manufactured iron and steel trades of the North of England have certified the average net selling price of iron rails, plates, bars, and angles for the two months ended February 29 last at 10*l*. 14s. 4.60d. per ton, as against 9*l*. 13s. 1.94d. for the previous two months. In accordance, therefore, with the sliding-scale arrangements there follows an advance of 1s. per ton on puddling and 10 per cent. on all other forge and mill wages, to take effect from Monday, March 27.

Messrs. J. R. Winpenny and James Cox, general secretaries to the Board of Conciliation and Arbitration for the North of England Manufactured Iron and Steel Trade, have issued their quarterly return, according to which the wages of the steel-mill men at the Consett Iron Company's Works will be advanced a further 5 per cent., bringing the rate up for the quarter just entered upon to 37½ per cent. above the standard. There were increases of 5 per cent. in the September and December quarters, and a 7½ per cent. advance was granted by the scale in the quarter ending June, last year. This is the highest point ever attained, the previous record under the existing sliding-scale being 27½ per cent. in December, 1900.

With further reference to the paragraph we reproduced on page 310 *ante* in regard to the cotton operatives' wages, the *Manchester Guardian* gives publicity to a statement from a mill manager, who, writing on the subject, says he admits that on paper there is an increased working margin between cotton and yarn. The cost of production, however, has increased so enormously that there is not such a margin as warrants the Operatives' Association applying for any advance in wages. He admits that the cost of living has greatly increased, but so also have the operative

spinners' wages, a bonus of 5 per cent. being given last July. To-day every mill is working understaffed, with the result that the wages paid per pair of mules is being divided between minder and one piecer, instead of minder and two piecers, the second piecer's wage going to the two others, with the result that they are producing less and the wages are greater. The piecer (a boy from 15 to 18 years of age) is receiving 28s. 3d. from twist mules and up to 32s. 6d. on weft mules per week, and the spinner is receiving 6s. to 8s. per week more than he did in pre-war times, his average wages for the past two weeks at certain mills having been 53s. per week net for 55½ working hours. The joiner, machinist, mason, boiler-maker, &c., will look enviously on such wages. The cost to work a modern mill to-day as compared with two years ago has increased over 5000*l.* per annum in rates, property tax, income-tax, and aircraft insurance, coal, stores, and the 5 per cent. advance in wages last July.

The Paris journal, *Le Génie Civil*, contains an interesting article by Mr. F. Bayle on wages. In this the author states that "in war time, on piece rates, and production remaining still far from its greatest possible maximum, the increase in the rapidity of production may lead to very high daily wages, because commercial laws enter no longer into play, the sole buyer being the State; in this case "systematic loitering and very high wages are superposed." The general, excessive, and unjustified increase in wages, bringing them to 400, 600, and 800 francs (16*l.*, 24*l.*, and 32*l.*) and more per month, in a number of factories of the provinces engaged in war work, are a source of economic, moral, and social disorders. The situation may have a grievous effect upon the soldiers at the Front, who may look with envy upon their comrades who have been called back to work in the factories.

A prominent Clyde shipbuilder, says the *Liverpool Courier*, makes the announcement that from his books he can prove that many Clyde shipyard workers are at present earning over 500*l.* a year, and are not paying one penny into the National Exchequer. Shipyard workers can easily make 10*l.* weekly, and even work less than the stipulated fifty-four hours weekly. Some squads of riveters—three men and a boy—have earned 32*l.* 10s. weekly since the war broke out, the weekly hours being only forty-eight.

The Swedish State assists workmen in visiting foreign countries to acquire knowledge of new methods, &c., through an annual grant, and even if such men often remain abroad longer than intended, they have hitherto been in the habit of returning to the home country the better and more skilled for their visits to foreign parts. Apprehending prohibitive steps against the emigration of labour after the war, the Stockholm trade unions have protested against any obstacles being placed in the way of Swedish workmen emigrating.

Owing to the widespread interest in the efforts of employers of labour to establish plans for sharing with employees some of the earnings of manufacturing, in addition to fixed regular wages, the National Civic Federation, says the *Iron Trade Review*, Cleveland, Ohio, has made an extensive investigation and analysis of more than 200 profit-sharing plants in the United States. Many of the experiments have been abandoned as acknowledged failures; others are still in existence with varying degrees of success and differ widely in their methods. The views of many labour leaders were obtained; they are unanimous in opposition to the general theory of profit-sharing, as they claim that the employers' real interests in such plans lie in their alleged usefulness as a means to weaken and disrupt the trade unions. In other words, the trade union has been and is resolutely for the payment of wages according to a certain fixed rule of so much per hour or day per man, no matter whether the work of one man is worse than that of another man or not.

About one-third of the companies whose plans have been analysed by the Federation report that they consider profit-sharing a success. Others presumably hold the same view, as they continue the experiment from year to year. Among reasons given by employers for their faith in the idea are that it promises more continuous service, reduces cost of production, secures more regular attendance at work, builds up confidence and creates a spirit of co-operation, gets rid of rolling-stones and encourages home-building, promotes efficiency, interest, and loyalty, and increases the profits of the business.

UNITED STATES STEEL CORPORATION.—The latest return of unexecuted orders held by the United States Steel Corporation beats all previous records, the total, which is brought down to February 29, coming out at 8,568,966 tons, as compared with 4,345,371 tons at the close of February, 1915, and 5,026,440 tons at the close of February, 1914.

THE SHORTAGE OF TONNAGE.

WHILE the whole of the civilised world has been unanimous in expressing horror at the outrageous method of warfare employed by the Teutonic nations in sinking merchant ships by means of submarines, some information may still be needed to convince people, even in this country, that the existing shortage of tonnage cannot be accounted for by the submarine "blockade." The necessary information is contained in a letter by Admiral Sir Cyprian Bridge recently published in *The Times*, from which the following particulars have been extracted.

The accompanying Tables I. and II. give the number and tonnage of merchant steamers and sailing vessels lost by the Allied nations from the commencement of the war up to March 23 last, and also give, for comparison, the total number and tonnage of vessels owned by those countries. It should be mentioned that, in addition to the losses shown in these tables, 246 trawlers have been lost by the Allies, and of these, 237 were owned by Great Britain, seven by France, and two by Belgium.

TABLE I.

Nationality.	Steamers Lost.		Steamers Owned.	
	Number.	Tonnage.	Number.	Tonnage.
British	379	1,320,171	10,218	20,830,918
French	41	139,865	1,016	1,909,609
Belgian	10	29,861	—	—
Russian	27	42,226	744	851,951
Italian	21	70,231	655	1,513,631
Japanese	3	19,267	1,155	1,826,068
Totals	481	1,621,621	13,788	26,932,177

TABLE II.

Nationality.	Sailing Ships Lost.		Sailing Ships Owned.	
	Number.	Tonnage.	Number.	Tonnage.
British	31	19,119	1135	443,150
French	12	18,323	523	376,119
Russian	8	7,463	512	202,511
Italian	6	3,373	522	222,914
Totals	57	48,278	1692	1,244,694

The loss of British steamers after nineteen months of war thus amounts to rather more than 6 per cent. of the total tonnage owned in this country, while the corresponding French losses come to just over 7 per cent. For Russia and Italy the losses of steam tonnage are about 5 and 4½ per cent. respectively. Commercial shipbuilding in belligerent countries has certainly been largely superseded by naval construction, but the ordinary losses of peace time have been more than made good by new construction. In 1915 the steam shipping of the United Kingdom was increased by 88 vessels, aggregating 343,616 tons, but a preponderating proportion of this tonnage is utilised for war purposes and not in regular trading. Although 41 French steamers, making 139,865 tons in all, were destroyed by the enemy, that country, at the end of last year, had only nine steamers and 12,574 tons less than in the previous year. Russian steamers decreased in number by three vessels during the same period, but the tonnage increased by 902, while in Italy there was an increase of 18 vessels and of 83,156 tons. Excluding warships, there were 432 steamers under construction in the United Kingdom, and this number, it should be noticed, is 53 in excess of the total number of steamers sunk by the enemy. The total British tonnage under construction amounted to 1,536,177, which is 216,006 more than the tonnage sunk; but here, again, it should be noted in connection with the measure of shortage that little or no progress is being made with the merchant work on hand, except such as is utilisable for war purposes.

Considering the figures for the whole of the Allied nations, it will be found that about 4 per cent. of the total merchant shipping of these countries has been destroyed; an even smaller percentage loss of neutral shipping has occurred, particulars of which will be given later. These small losses, even if not made good by new construction, could easily be compensated for by improved organisation; a saving of two days in a round voyage of seven weeks would be sufficient for the purpose.

TABLE III.

Country.	Steamers.		Sailing Ships.	
	Number.	Tonnage.	Number.	Tonnage.
Norway	59	95,732	22	19,780
Denmark	18	32,734	10	1,566
Sweden	33	42,086	7	2,028
Holland	22	73,786	2	226
United States	6	16,013	1	176
Greece	11	22,383	—	—
Spain	4	8,606	—	—
Persia	1	758	—	—
Portugal (whilst still neutral)	1	623	—	—
Roumania	—	—	1	285
Totals	155	292,721	43	24,061

We have also available a number of ships which in peace times were engaged in trading with German ports. Admiral Bridge calculates that the number of British ships so employed would amount to about 500, and their tonnage, he considers, would be about 579,000. If to these are added the ships trading to the non-German Baltic ports, to Constantinople and the Black Sea, the total tonnage would be found to be in excess of that destroyed by the enemy. It will thus be evident that the shortage is not due to the action of hostile submarines, and can only be accounted for by the enormous requirements of the naval and military services, which, according to the latest published statement, employ no less than 3100 vessels.

Table III. shows the losses of merchant shipping sustained by neutral nations at the hands of the Teutonic Powers.

Eight neutral trawlers, seven of which were Dutch and one Danish, have also to be added to these losses. Although the losses are serious enough for the countries concerned, and would undoubtedly have been much greater but for the activities of the British Navy, they form an almost insignificant fraction of the total merchant shipping of the world. The above statistics clearly prove that, up to the present, our enemy's barbarous method of warfare has been very far from attaining its avowed military object, and we have no shadow of doubt that the more strenuous efforts threatened will be rendered equally futile by the resources of our naval authorities.

MANGANESE.—The imports of manganese into the United States in December were 69,274 tons; this was the largest monthly total since the outbreak of the war, the largest monthly receipts previously recorded being 57,667 tons in August, 1915. The total imports for last year were 320,782 tons, as compared with 283,294 tons in 1914, and 345,090 tons in 1913. The value of last year's imports was 2,633,286 dols. The production of manganese in the United States last year is estimated by the United States Geological Survey at 6000 tons, as compared with 2635 tons in 1914. Important exploratory operations were carried on last year, but were not attended with the results anticipated. The imports of manganese into Great Britain in January, this year, were 32,111 tons, as compared with 39,413 tons in January, 1915.

WAR PROFITS IN GERMANY.—The Mix and Genest Company, which make a speciality of telegraphs and telephones, earned in 1915, a surplus of 2,650,101 marks, against 1,201,725 marks in 1914, and 293,053 marks in 1913, the dividends being respectively 18, 12, and 4 per cent., the writings-off 806,495, 368,986, and 153,055 marks respectively, these sums not being included in the surplus; 700,000 marks have been added to the reserve, against 500,000 marks in 1914 and 6000 marks in 1913, and from last year a sum of 1,019,000 marks is being carried forward to meet war tax, &c. The Upper Silesian Railway Material Company pays 10 per cent. for last year, against 2 per cent. for the preceding year, the writings-off amounting to 6,008,506 marks, against 3,604,165 marks for 1914. Prospects for the current year are satisfactory, and the company is taxed to the fullest extent of its capacity. The Niederschöneweide Works, which make a speciality of handling old metal scrap, copper, tin, and aluminium, hold the record for dividend (and bonus) so far. The company, as such, only dates from 1914, in October last year the share capital was increased from 1,450,000 marks to 3,000,000 marks, and for 1915 all the shareholders receive a dividend of 16 per cent. and a bonus of 84 per cent., making, it will be seen, 100 per cent. The Magdeburg Machine-Tool Company, only formed last year, with a capital of 20,000 marks, afterwards increased to 1,700,000 marks, pays a dividend of 15 per cent. (255,000 marks) writes off 294,266 marks, and reserves 250,000 marks as war reserve, all expenses, including starting, having been provided for.

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HAND BOOK.—We have received a copy of the thirty-fourth annual edition of the *Electrician* Electrical Trades Directory and Hand-Book, known throughout the world's electrical industry as "The Big Blue Book." It is regularly published at the end of February, and is corrected close up to the moment of publication. It contains complete notes of the year's progress in electric traction on railways and tramways, electric power transmission schemes, the applications of electric driving to industrial work, including textile mills and factories, collieries, engineering works, &c.; also developments in submarine and land telegraphy, a record of radiotelegraphy progress, and the salient features of telephone progress during 1915; also the development of the steam-turbine and the internal-combustion engine, the progress made in arc, metal-filament, drawn-wire, and half-watt lamps, &c. The law of electric lighting, electric power, electric traction, telegraphs, and telephones is fully dealt with, and a full digest specially prepared for this Directory and Hand-Book by Mr. A. C. Curtis-Hayward, B.A., A.I.E.E., solicitor, is given. The principal legal decisions in 1915 affecting the electrical industry, and a summary of the Parliamentary work of the past session so far as legislation has affected the electrical industry, are included, together with much other interesting information. The directory division contains the name and address of practically every person engaged in the electrical profession and industry throughout the United Kingdom, their telephone numbers and telegraphic addresses; also a separate list of telegraphic addresses (alphabetically arranged). Sections are devoted to the British Colonies, to the Continent of Europe, to Asia and Africa, Central and South America, and the United States. The biographical division gives sketches of the careers of the leaders of electrical engineering enterprise at home and abroad. The book is published at the price of 15s. net by the *Electrician* Printing and Publishing Company, Limited, 1, 2, and 3, Salisbury-Court, Fleet-street, E.C.

THE PRESENT CONDITIONS OF ARTERIAL DRAINAGE IN SOME ENGLISH RIVERS.*

By RICHARD F. GRANTHAM, M. Inst. C.E.

THE subject of this paper was suggested by a reference, in the President's inaugural address in November, 1915, to the want of a single controlling authority or Conservancy Board over rivers whose valleys are liable at times to extensive floods. In 1913 the author and Mr. C. Bidwell were appointed by the Board of Agriculture and Fisheries as Special Commissioners to inquire into and report upon the conditions affecting arterial drainage in certain river valleys on the East side of England, and had opportunities of observing many of the engineering features in the river systems. The rivers examined were: in the East Norfolk district, the Bure, the Yare, and the Waveney; in the Fen and Marsh districts in Cambridgeshire, Norfolk, and South Lincolnshire, the Great Ouse, the Welland, and the Witham; as well as some others in different parts of the country.

In the East Norfolk district the area drained by the rivers and their tributaries is 786,000 acres, and the area within the watersheds liable to flooding and injury by flood is approximately 74,000 acres. The low land, most of which is embanked, lies below or near the level of high water of ordinary spring tides at Great Yarmouth, and all the water from the rivers is discharged through the narrow channels of the Yare past Great Yarmouth. After the floods of August, 1912, Mr. Arthur Collins, City Engineer of Norwich, reported to the Corporation on the improvement of the river between Norwich and Yarmouth, and recommended works of deepening and cutting off bends, &c., at an estimated cost of 350,000*l.*

Simultaneous tidal observations made by Mr. Collins in 1901 showed that the level of high water at New Mills, Norwich, was 2 ft. 6 in. lower than it was at Gorleston Pier Head, and that when the tide had fallen 7 ft. 11 in. at the Pier Head it had risen 6 in. at New Mills. Sir John Coode, in reporting on the River Nene, found similar conditions, the level of high water being 7 ft. lower at Peterborough than it was at Stone Ends, at the outfall of the river. Mr. W. H. Wheeler also showed that the level of high water in an extreme flood at Denver Sluice was lower than it was 13 miles lower down the river.

A further proposal for relieving the floods in the Yare and Waveney valleys was to erect a sluice by the lock at Mutford Bridge, so as to allow the flood-water to be discharged through Lake Lothing into the sea at Lowestoft much earlier than it could be discharged through Yarmouth. Those interested in these proposals are the Great Yarmouth Port and Haven Commission, the Norwich Corporation, and the owners of land on the banks of the Waveney and Yare. The Great Yarmouth Port and Haven Commission is the sole authority having power to deal with the rivers, but only in respect of navigation. It derives its existence and powers from an Act of 1835, and its powers for dealing with the three rivers are delegated to three bodies of River Commissioners. The flooding of the low-lying marshes arises in flood times chiefly from the bursting of the embankments, which are made of very poor material.

The difficulty of making improvements for drainage purposes is the comparatively small area of land which could be rated sufficiently in order to raise funds for the heavy cost of the works. The drainage of the Middle Level is referred to as showing the want of a catchwater drain to intercept the high land water.

The Great Ouse drains about 2,000,000 acres, but the area ratable for maintenance and improvement is approximately 364,000 acres, included in the areas governed by the Middle Level and South Level. In the reign of Charles I. an agreement was made for draining the great Level of the Fens, and this was followed by an indenture by which the Earl of Bedford and other proprietors of 300,000 acres of land were to contribute to the costs of the works. Large drains were then cut, and subsequently part of the tidal portion of the river was straightened, completing the system now in existence. It is well known that the surface of the fen land is subsiding. On the other hand, the rivers have been gradually silting up, and for many years nothing except a little dredging has been done to improve them. The control of the river is divided amongst several authorities, some having power over the bed, some over the banks, and others over the bed and banks. Recent soundings show that some parts of the bed have silted up, and the Admiralty survey in December, 1913, showed that in the channel opposite the Bull Dog Sand, below the outfall of the river, there is only 1 ft. of water at low water of spring tides. The making of a straight cut to cut off the Magdalen bend above St. Germains has long been recommended by engineers, and the work would undoubtedly give relief to the floods above.

The Land Drainage Act, 1914, gives power to the Board of Agriculture and Fisheries, by a Provisional Order passed in 1915, to form a single body over the tidal portion of the river up to Denver Sluice, and the Order specifies certain works to be done in that part of the river, such as the extension of the training-banks at the outfall, and the cutting off of the Magdalen bend.

In the non-tidal portion of the Great Ouse the river is described to be in a very neglected condition up to Bedford, and the valley, particularly at St. Ives and Huntingdon, is very severely flooded at times.

The Nene between its outfall into the Wash and Peterborough contains many obstructions, particularly through Wisbech and from that town up to Peterborough. As in the case of the Great Ouse, the difficulty in the way of improvement is the division of authority. The Car Dike, which should form the catchwater drain, has been neglected and in some parts abandoned.

The Welland is under the jurisdiction of the Welland Outfall Trustees, who administer and have the power of rating 82,000 acres, including 30,000 acres of the interior district, the drainage of which is governed by the Deeping Fen Trustees. An opportunity of improving the outfall of the channel was lost, owing to lack of funds, when the new cut of the Witham Outfall was made. When the Witham Improvement Outfall Act was passed a clause was inserted by which the Witham Outfall Board was to contribute 20,000*l.* towards the new cut for the Welland, if within twenty years the Trustees expressed their wish to undertake the work. The River Glen, the main tributary of the Welland, is also subject to divided authority in the control of its bed and banks, so that nothing has been done for many years to improve it, although the embankments on both sides have been seriously breached.

The condition of the Witham and of the areas drained by the sluices discharging below Boston was much improved by the new cut of the outfall into Clay Hole, but a large area above the Grand Sluice up to and above Lincoln is still frequently and seriously flooded. Several authorities have control of that length of it, and the area draining through the Grand Sluice is comparatively small, so that the rate that could be equitably levied would be insufficient to cover the cost of the works. Relief would be given to the drainage by the opening up of the Car Dike, a catchwater drain cut by the Romans between Lincoln and Peterborough. The difficulty of maintaining and keeping clear of stones and débris brought down from mountain districts into rivers fed from these sources, and the remedies that have been suggested, are referred to.

The failures that have so far attended the establishment of Conservancy Boards for relieving by improved drainage the areas subject to flood are described, and instances are cited of the opposition of the owners of the higher lands to any proposal for laying those lands under contribution for the relief of the low-lying lands. Two cases are cited of the formation of large drainage districts under private Acts of Parliament—viz.: The Thames Valley Drainage Act, 1871, and the Somersetshire Drainage Act, 1876, under which only the lands actually flooded or lands very near the level of floods are rated for improvements in the rivers and drains.

A survey of the rivers and valleys inspected showed in many instances neglect in the maintenance of the drains, which in areas so flat is all important; but the great difficulty in the way of real improvement on a sufficiently large scale is either the want of any authority at all, or the multiplication of authorities over the same river, without power of improving it as a whole.

The hope is expressed that under the Land Drainage Act, 1914, the Board of Agriculture and Fisheries may be enabled to issue Provisional Orders for improvements in other rivers besides the Great Ouse, although in order to complete a conservancy system in any river further legislation may ultimately be required.

* Abstract of a paper read at the Institution of Civil Engineers on Tuesday, April 4, 1916.

WORKMEN'S COMPENSATION CASES.

Amount Payable in Case of Partial Employment.—A workman who had been employed for over twelve months as a jobbing gardener by a Tunbridge Wells surgeon, working two days a week at the rate of 10s. per week, met with an accident which resulted in the loss of an eye whilst trimming an hedge in the surgeon's garden. The man earned, in addition, about 6s. per week at other jobs, 10s. in cutting and selling firewood, and 3s. from his own garden produce. The County Court, under the Workmen's Compensation Act, 1906, decided that a jobbing gardener would earn in the Tunbridge Wells district from 25s. to 30s. per week, and made an award in his favour of 12s. 6d. per week. The surgeon appealed. In the Court of Appeal the Master of the Rolls stated that the case was a plain one. The question was, What was the compensation to which the workman was entitled? By Section 1 (*b*) of the First Schedule of the Act, the amount of compensation, where total or partial incapacity resulted from the accident, was "a weekly payment during the incapacity not exceeding 50 per cent. of his average weekly earnings during the previous twelve months." In the present case, the Court knew to a penny what the workman had earned, and all that they had to do was to add up the wages earned during twelve months from the same employer. There was no difficulty, and if it rested at that, the amount would be calculated on the wages received from Dr. Abbott for twelve months. It was said that the Court ought to have regard to the fact that the man's income was derived partly under a contract of service within the Act and partly from doing other work which was not within the Act. His Lordship could not agree with that view. The appeal must be allowed. Lord Justice Phillimore and Mr. Justice Sargant agreed.

"In Course of," but not "Arising Out of, Employment."—In the Court of Appeal, the Master of the Rolls, Lord Justice Phillimore, and Mr. Justice Sargant, decided a curious point in a claim under the Workmen's Compensation Acts, upon the appeal of Mr. S. W. Skelton, the owner of a Plymouth schooner, from an award of Judge Lush Wilson, given at the Plymouth County Court in favour of the applicant, Francis Blake Chapman, a mariner.

Chapman was employed as captain of the schooner, and Skelton, the owner of the vessel, was acting as captain's mate. While the schooner was lying at the Victoria Docks, London, Chapman and Skelton went on shore to get stores and provisions, and on returning, the captain stepped on a piece of orange-peel, fell, and fractured a thigh-bone. His injury incapacitated him for a time from continuing his calling as a mariner, and he instituted the present proceedings on the ground that the accident arose out of and in the course of his employment. The County Court Judge made an award in the captain's favour for 1*l.* a week compensation, to continue during total or partial incapacity, and from that decision Skelton, the owner, appealed.

The Master of the Rolls said he would assume the accident arose in the course of Chapman's employment, but he could not understand how it could be said it arose out of his employment. The risk of stepping on orange-peel was one to which everybody in the Metropolis was exposed. It would be contrary to a long list of authorities to hold that in the circumstances the accident "arose out of the employment."

Lord Justice Phillimore and Mr. Justice Sargant concurred, and the appeal was therefore allowed.

Fatal Cycling Accident.—In a case recently heard in the Court of Appeal before the Master of the Rolls, Lord Justice Phillimore, and Mr. Justice Sargant, an employer successfully appealed against an award in favour of the widowed mother of an employee who was killed by a motor-car while riding a bicycle on the high road from Northfleet to Rochester. The employer, who was a solicitor with an office in Rochester, had to attend weekly at a Court held in Northfleet, and the employee, a clerk, also attended the Court to assist his employer. When the trains were not convenient, the employee sometimes made the journey between Northfleet and Rochester on his bicycle, a fact of which his employer was aware and did not disapprove, and it was on one of these occasions that the fatal accident occurred. The judge of the Kent County Court held that the peril encountered was a special risk of the employment, and that the accident arose "out of the employment." He therefore awarded compensation to the employee's sole dependent, and it was against this award that the employer appealed.

In delivering judgment, allowing the appeal, the Master of the Rolls pointed out that the employer had not directed the clerk to use his own bicycle in preference to the public conveyance by train, and that there was no peculiar risk in travelling on the main road from Rochester to Northfleet. Neither was there any ground for the suggestion that a bicycle was itself so dangerous that the permission granted for its occasional use made the employer liable for the consequences of an accident on the road. It therefore became a question of law as to whether the accident arose out of the employment, and, in his Lordship's opinion, it did not. His Lordship also pointed out that it must not be assumed that the result would have been different if the employer had directed the clerk to use his bicycle on the day of the accident. He therefore allowed the appeal, and Lord Justice Phillimore and Mr. Justice Sargant delivered judgments to the same effect.

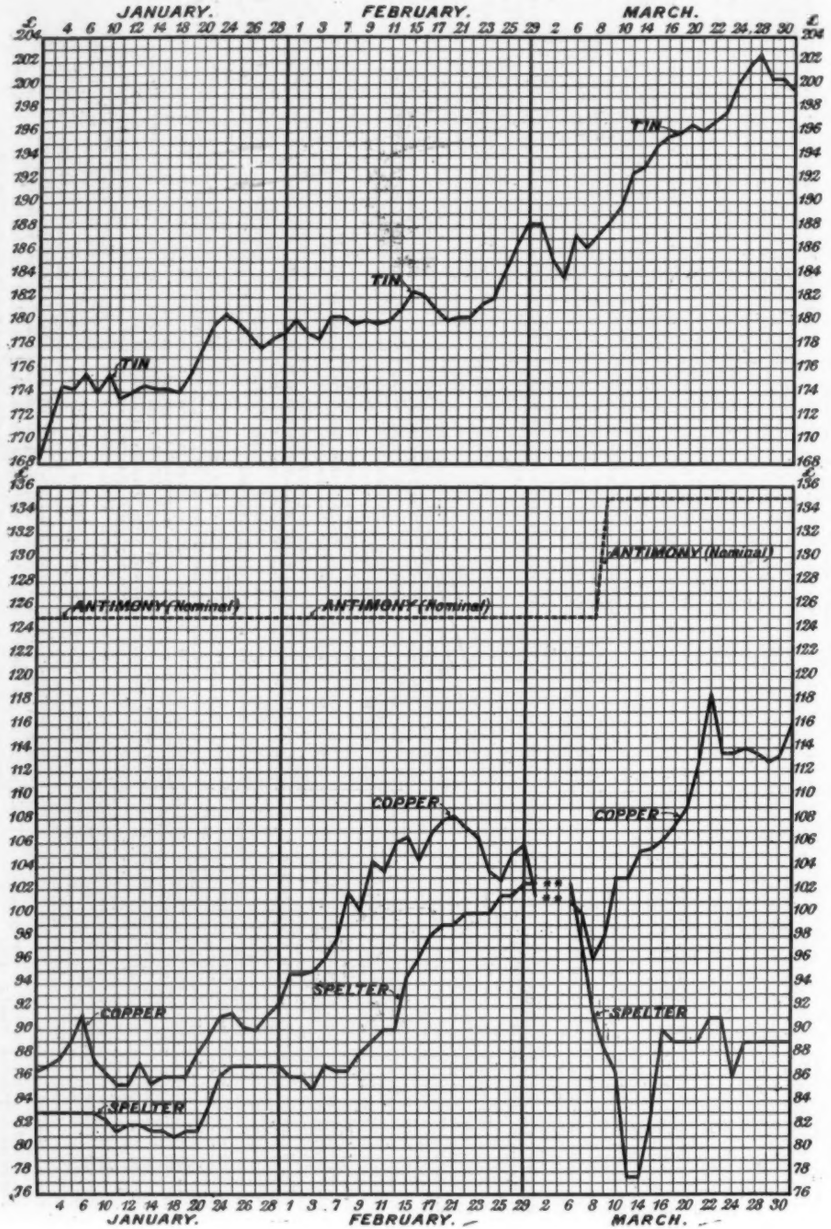
ELECTRIC FURNACE FOR STEEL FOUNDRY.—A 3000-lb. Snyder electric steel furnace is being put down in the foundry of the Sivyer Steel Casting Company, Milwaukee, Wis., says the *Iron Age*, to supplement the present converter. The tendency of the cupola metal to run up in sulphur will be counteracted by subsequent treatment in the electric furnace, the metal being finished in the latter furnace following the first blow in the converter.

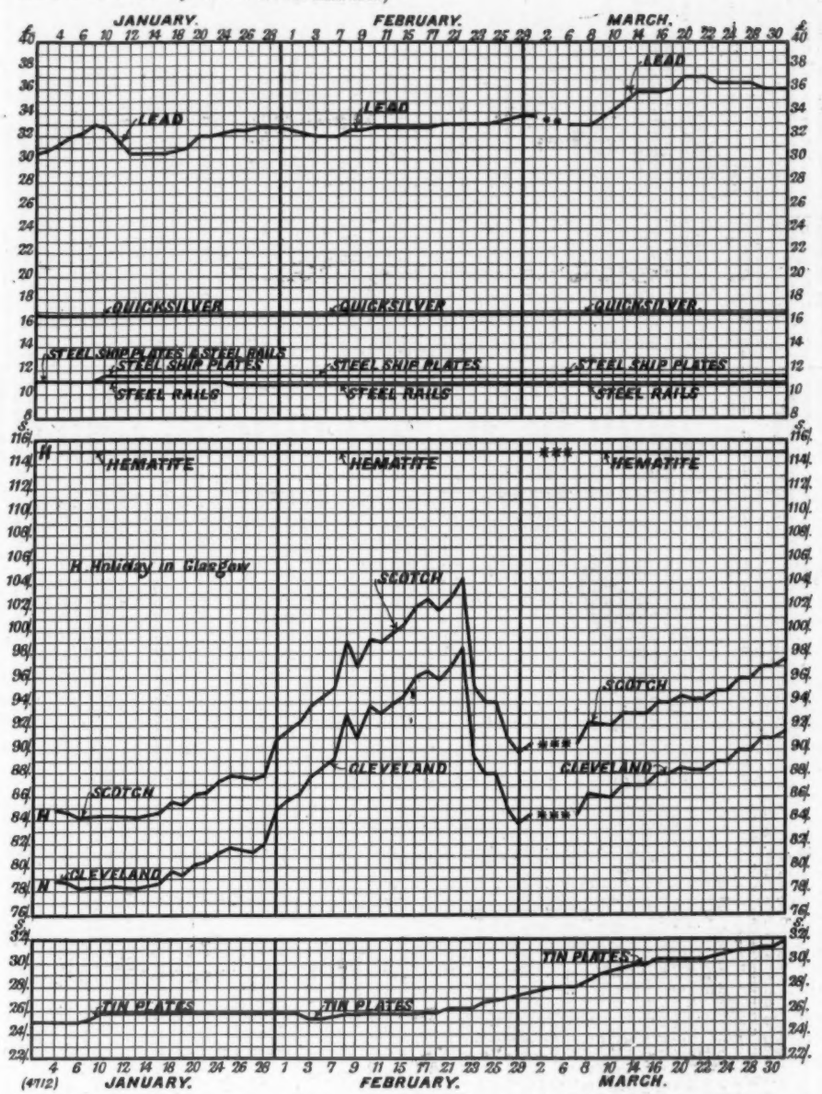
DIESEL ENGINE USERS' ASSOCIATION.—At the March meeting of this Association the secretary read a report made to Lloyd's Underwriters by Mr. P. H. Smith on the explosion of an air-compressor of a Diesel engine in the plant of the Smithfield Markets Electric Supply Company. The accident occurred on February 16 last, and resulted in the death of one man. The compressor was of the quadruplex type, with two low-pressure cylinders, one intermediate-pressure cylinder, and one high-pressure cylinder. The explosion was in the intermediate-pressure receiver, and, in Mr. Smith's opinion, it was caused by the spontaneous ignition of oil vapour in the receiver. Several recommendations relating to the design and method of operating compressors in order to avoid similar accidents in the future were contained in the report. The next meeting of the Association will be held on Wednesday, the 12th inst; further information and particulars of the Association and its work can be obtained from the honorary secretary, Mr. Percy Still, of 19, Cadogan-gardens, London, S.W.

MODERN COAL AND COKE-HANDLING MACHINERY, AS USED IN THE MANUFACTURE OF GAS.—On the 3rd inst., at a meeting of the Society of Engineers (Incorporated), a paper was read by Mr. J. E. Lister, Wh.Ex., Assoc. M. Inst. C.E., on "Coal and Coke-Handling Machinery for the Manufacture of Gas," in which the author explained the magnitude and expense of the task of dealing with the large quantities of coal and coke that have to be handled in large gas-works, and the consequent need for labour-saving machinery. The author dealt with the arrangement of wagon-tippers, and coal-breaking, screening, and elevating plants. The latest methods of carbonisation in vertical retorts and coke-ovens necessitate new types of coal and coke-handling machinery. In the case of vertical retorts, the types of plant used are similar, but modified to suit the altered conditions. In the case of coke-oven plants, which are being used for supplying town's gas at Birmingham and Middlesbrough, the charges are much heavier, and different methods of charging the coal and dealing with the coke are used. Charging-machines, levellers, and discharging-rams were described and illustrated. In many cases the coke is quenched and loaded by hand, but mechanical methods are now becoming more general.

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN PRICES OF METALS.

(Specially Compiled from Official Reports of London Metal and Scotch Pig-Iron Warrant Markets.)





* On March 1 an Order made under the Defence of the Realm Act prohibiting speculative dealings in copper, antimony, spelter, lead, iron, and other metals required for war work, was published in the *London Gazette*. In consequence of this Order business in these metals was suspended on the London Metal Exchange, and also on the Glasgow Pig-Iron Warrant Market, on the following day. The Order, however, was not intended to restrict legitimate trading, and business of this kind was therefore resumed in London on March 6 and in Glasgow on March 7.

SOME TIN-ALUMINIUM-COPPER ALLOYS.*

By Professor A. A. READ, D. Met., F.I.C., and R. H. GREAVES, M.Sc. (University College, Cardiff).

THE work described in the present communication was mostly carried out in the early part of 1914, and was intended to form a preliminary survey of the possibly useful alloys of tin, aluminium, and copper. The authors are inclined to believe that the characteristics of these alloys revealed in this work do not encourage much hope of their commercial utility. At the same time, while they are not so good as some have anticipated, they are certainly not so bad as others have asserted; and as the authors do not intend to proceed further with the study of these alloys, it is hoped that a record of the work as far as it has been carried may be of some value.

The constitution of the alloys of copper, tin, and aluminium has been investigated by Edwards and Andrew,† who employed microscopic examination, supplemented by pyrometric methods. As a result of their work, these authors deduced certain conclusions of practical interest, and those which relate to the alloys at present under consideration were as follow‡:—

"1. Judging from the constitution and general appearance of the alloys, it is quite obvious that those possessing reasonable mechanical properties are confined to two very limited areas—viz., those consisting largely of the α phase, and those which consist of the η phase. All the others are very brittle, and in far the greater number the tin does not mix to form homogeneous alloys.

"2. . . . no advantage is to be gained by adding tin to those alloys of aluminium-copper which contain Cu_2Al.

"3. . . . so far as the α range is concerned, it is reasonable to expect that the substitution of aluminium for tin within certain limits will tend to improve the properties of the alloys. . . If this prediction is proved to be correct by experiment, then an alloy containing about 6.5 per cent. of aluminium and 5.5 per cent. of tin by weight will have the same properties as an alloy containing 10 per cent. of tin and 90 per cent. of copper. Such a ternary alloy would be cheaper than the copper-tin, and would also have a lower specific gravity."

TABLE I.—*Tensile Tests on Aluminium-Tin-Copper Alloys (Guillet).*

Composition.			Yield-Point.	Maximum Stress.	Elongation.	Reduction of Area.	Relative Hardness.
Copper.	Tin (by Difference).	Aluminium.					
p.c.	p.c.	p.c.	tns. p. sq. in.	tns. p. sq. in.	p.c.	p.c.	
90.93	9.00	0.07	7.4	14.7	26.2	34.0	50
88.66	9.87	0.47	5.7	9.9	2	1.4	57
89.54	9.70	0.76	4.8	8.1	2	0.0	61
89.05	8.74	2.21	4.8	8.1	2	2.8	63
90.71	5.18	4.11	4.1	6.2	5	12.5	65
89.10	3.59	7.31	7.8	10.7	3	13.0	63

It certainly appears that if these alloys have any practical value, it must lie in the direction indicated in the third of these conclusions; for unless the addition of small quantities of tin to the aluminium-copper alloys should lead to a very marked improvement in their properties, the high price of tin would effectively limit their application. The addition of a very small quantity of aluminium to gun-metal in order to act as a deoxidiser is generally held to be advantageous.

H. von Miller* found that the addition of aluminium to bronze containing 92 per cent. of copper and 8 per cent. of tin increased the shrinkage and diminished the facility with which a patina was formed.

Guillet† gives tests (Table I.) made on (cast?) bars of aluminium-tin-copper alloys, all containing about 90 per cent. of copper. The results show that, although a trace of aluminium has little influence on gun-metal, when the amount reaches 0.4 per cent. the detrimental effect on the strength, and especially on the elongation, is very great (see Table I.). Guillet also states that although the hardness is almost unaffected, the brittleness increases rapidly as aluminium replaces tin. The results of Guillet appear to be affected by a very serious error (possibly the presence of oxides), as the authors' castings invariably showed better mechanical properties, though Guillet's general conclusions and figures for relative hardness are confirmed.

PREPARATION AND ANALYSIS OF ALLOYS.

The materials used in the preparation of the alloys examined were:—

Cathode copper of very high purity, obtained from Messrs. Vivian and Sons, Swansea.

Aluminium from the British Aluminium Company, containing:—

Silicon	...	...	...	0.17 per cent.
Iron	...	...	...	0.18 ,,
Sodium	...	...	...	0.05 ,,
Aluminium (by difference)		...		99.60 ,,

The Cornish Tin-Smelting Company's best refined tin, which gave on analysis:—

Lead	...	...	...	0.003 per cent.
Copper	...	...	...	0.004 ,,
Bismuth	...	...	...	Nil.
Iron	...	...	...	0.024 per cent.
Zinc	...	...	...	Trace.
Sulphur	...	...	...	0.015 per cent.
Arsenic	...	...	...	0.023 ,,
Antimony	...	...	...	Not estimated.
Tin (by difference)		...	...	99.92 per cent.

Small trial ingots weighing about 500 grammes, and containing varying amounts of copper, tin, and aluminium, were cast in open chill moulds. All these alloys were prepared by melting the copper under charcoal and stirring well with a carbon rod. A portion of the aluminium was then added, afterwards the tin, and finally the remainder of the aluminium. The ingots were analysed, the tin present being estimated by weighing as SnO_2, in accordance with the usual method of determining tin in bronzes. The copper was determined by the thiosulphate method, and the aluminium taken by difference.

Table II. shows the composition of the alloys, together with their relative hardness obtained with the Shore scleroscope using the universal hammer, and the results of the cold-bending test described below.

Hardness.—In every case with constant aluminium the hardness increases with increase of tin; with constant tin it increases with increase of aluminium. Within an area roughly corresponding to the limits of the α solution the hardness depends solely on the amount of copper present. The results contained in Table II. are shown in Fig. 2.

Cold-Bending Tests.—Cast strips were used having the approximate dimensions 2.5 in. by 0.6 in. by 0.35 in. They were nicked at the centre, bent cold in a vice, and hammered over on an anvil. The results are shown in Table II. and Fig. 3, where the word "tough" has reference to the capability of the alloy to bend ("very tough" indicates a cold bend through 180 deg. unbroken), and "hard" refers only to the difficulty of bending or breaking by blows of the hammer. The diagram bears considerable resemblance to the hardness diagram, the behaviour of the alloys being largely determined by the copper content. It may be noted, however, that for the series containing 90 per cent. of copper, the toughness, as measured by the angle of bend, of each binary alloy is reduced by the addition of the third metal.

Hot-Forging Tests.—Small blocks of metal, having the dimensions 1½ in. by 1 in. by ⅝ in. thick, were forged down hot to a thickness of 0.2 in. to 0.3 in. under a steam-hammer. The results of the first test made after heating to about 750 deg. Cent. are shown in Fig. 4. It was not anticipated, of course, that the alloys rich in tin would stand this treatment, but the whole series was forged in order to obtain comparative results. The alloys which forged well at this temperature are those low in tin; in fact,

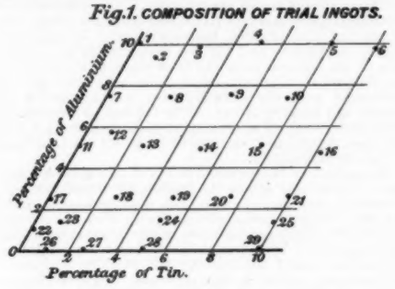


Fig. 1. COMPOSITION OF TRIAL INGOTS.

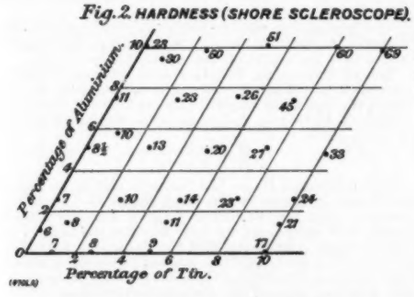


Fig. 2. HARDNESS (SHORE SCLEROSCOPE).

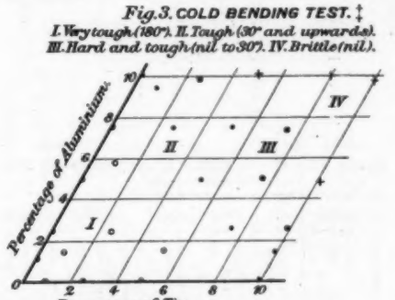


Fig. 3. COLD BENDING TEST.‡
I. Very tough (180°). II. Tough (30° and upwards). III. Hard and tough (nil to 30°). IV. Brittle (nil).

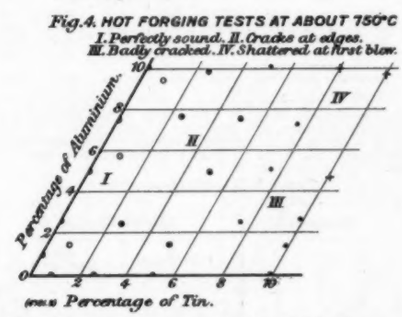


Fig. 4. HOT FORGING TESTS AT ABOUT 750°C
I. Perfectly sound. II. Cracks at edges. III. Badly cracked. IV. Shattered at first blow.

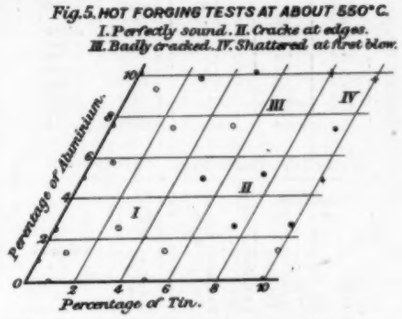


Fig. 5. HOT FORGING TESTS AT ABOUT 550°C.
I. Perfectly sound. II. Cracks at edges. III. Badly cracked. IV. Shattered at first blow.

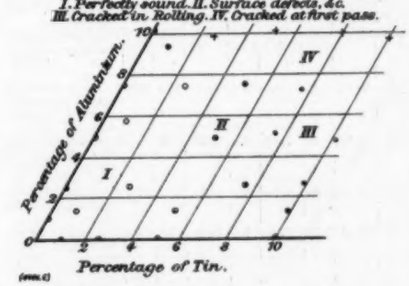


Fig. 6. COLD ROLLING TESTS.
I. Perfectly sound. II. Surface defects, &c. III. Cracked in Rolling. IV. Cracked at first pass.

TABLE II.

No.	Composition. Copper per Cent.	Tin per Cent.	Aluminium per Cent.	Scleroscope Hardness.	Angle of Bend.	Fracture.
					deg.	
1	89.9	—	10.1	23	120	Pale gold; very finely crystalline.
2	89.9	1.1	9.3	30	30	Pale gold.
3	87.6	2.6	9.8	50	Almost nil	Coarsely crystalline; bright facets.
4	84.8	5.1	10.1	51	Nil	Grey; finely crystalline.
5	82.0	8.0	10.0	60	,,	Grey; finely crystalline to conchoidal.
6	80.2	10.0	9.8	69	,,	Silvery grey; very finely granular; almost silky.
7	92.5	—	7.5	11	180	Unbroken.
8	90.0	2.6	7.4	23	90	Gold; coarsely granular.
9	87.4	5.1	7.5	26	30	Gold; very finely granular.
10	85.1	7.5	7.4	45	Almost nil	Brownish; very finely granular.
11	95.0	—	5.0	8.5	180	Unbroken.
12	93.3	1.0	5.7	10	180	,,
13	92.5	2.5	5.0	13	—	
14	90.0	5.1	4.9	20	90	Yellowish grey; columnar.
15	87.4	7.5	5.1	27	10	Grey; inclined to columnar.
16	85.2	10.1	4.7	33	Nil	Grey; very finely crystalline to conchoidal.
17	97.5	—	2.5	7	180	Unbroken.
18	94.9	2.6	2.5	10	180	,,
19	92.4	5.1	2.5	14	—	
20	89.9	7.5	2.6	23	45	Brownish; fine granular.
21	87.5	9.9	2.6	24	10	Grey; very fine granular; almost silky.
22	99.0	—	1.0	6	180	Unbroken.
23	97.7	1.0	1.3	8	180	,,
24	93.5	5.1	1.4	11	180	,,
25	88.8	9.9	1.3	21	45	Grey, yellow spots; granular (? not homogeneous).
26	99.0	1.0	—	7	180	Unbroken.
27	97.5	2.5	—	8	180	,,
28	94.9	5.1	—	9	180	,,
29	90.1	9.9	—	17	90	,,

* Paper read before the Institute of Metals, Wednesday, March 29, 1916.

† Journal of the Institute of Metals, 1909, No. 2, vol. ii., pages 29 to 58; ENGINEERING, November 19, 1909.

‡ *Loc. cit.*, page 42.

* *Metallurgie*, 1912, vol. ix., pages 63 to 71.

† Guillet, *Les Alliages Métalliques*, 1906, page 571.

‡ In this and the following figures the character of the mark used to represent the alloy indicates to which class it belongs. The areas, of course, merge into one another, and no boundaries are filled in, as they could convey nothing further than inspection of the individual points marked.

they all contained not more than 1 per cent. of this constituent. A second series of alloys was forged at a scarcely visible red, about 550 deg. Cent. At this temperature the area covered by the forgeable alloys was extended (Fig. 5). With regard to alloys 1 and 2, containing 10 per cent. of aluminium alone and with 1 per cent. of tin, though they remained sound, they were very hard to forge at this temperature and required several re-heatings. The same applies to No. 9 (aluminium, 7½ per cent.; tin, 5 per cent.), which is also a two-phase alloy at this temperature.

The results here given are sufficient to indicate that the difficulties of hot-working the ternary alloys are greater even than those experienced with bronzes, and far greater than with the aluminium-copper alloys.

Cold-Rolling Tests.—Pieces having the approximate dimensions 2·5 in. by 0.6 in. by 0.35 in. were cut for rolling. These were rolled cold, with the necessary annealings, if possible to a thickness of 0.1 in., and the surface and edges examined. The temperature of annealing exercised an important influence on these tests; alloys rich in aluminium could be annealed at a much higher temperature without detriment to their behaviour on rolling. The conditions of annealing were therefore modified to suit the material in each case, and the results are shown in Fig. 6.

Corrosion Tests.—Table III. (above) shows the results of corrosion tests in fresh water and sea-water carried out through a period of sixteen weeks.*

In fresh water the aluminium-rich alloys were slightly tarnished, the tin-rich alloys more or less pitted. In sea-water the aluminium-rich alloys showed a thin, firmly adherent red deposit; those rich in tin showed a number of green patches, easily removed, with a red deposit beneath. With low tin and no aluminium a bright red, easily detachable coating was formed.

Tensile Tests.—The alloys were tested in the form of standard test-pieces turned down from chill castings 1 in. in diameter and 10 in. long, both as cast and in the annealed state. The results are shown in Tables IV. and V.

Although the mechanical properties are in many cases good, they never reach those of the corresponding (and cheaper) aluminium-copper alloys. No. 3 (consisting micrographically of almost α solution) is not susceptible to deterioration by annealing like the 10 per cent. aluminium-bronze. The fact is brought out in Table VI., which shows the mechanical tests on a series of alloys with an approximately constant copper content. The results indicate that the replacement of tin in a gun-metal by aluminium is of no advantage, but leads to loss of strength and greatly increased brittleness, unless about three-quarters at least of the tin is replaced, when the properties approximate, but are inferior, to those obtainable from aluminium and copper alone.

Hardness determinations were made on these alloys both by the scleroscope and by Brinell's method. The figures given in Table VII., in addition to confirming the conclusions given under "Hardness" above, indicate that none of the alloys, except No. 1, undergoes hardening by quenching.

Micrographically they all, except No. 1, consist of a single phase, the annealed bars showed a practically homogeneous α solution. No. 1, however, contains + β (it is practically identical in structure with micrograph No. 14 of Edwards and Andrew's paper), and is hardened by quenching from 760 deg. Cent., but only in the ratio of 26 : 43 as against 21 : 62 for the 10 per cent. aluminium-copper alloy.

TABLE III.—CORROSION TESTS.

No.	Composition.			Loss in Weight.							
				Pound per Square Foot per Month.				Grains per Square Foot per 100 Days.			
				Sea-Water.		Fresh Water.		Sea-Water.		Fresh Water.	
	Copper.	Tin.	Aluminium.	Annealed.	Cold-Rolled.	Annealed.	Cold-Rolled.	Annealed.	Cold-Rolled.	Annealed.	Cold-Rolled.
	per cent	per cent	per cent.								
1	89.9	—	10.1	0.00080	0.00051	0.00007	0.00006	19	12	2	1
2	89.6	1.1	9.3	0.00036	0.00042	0.00006	0.00005	8	10	1	1
3	87.6	2.6	9.8	0.00020	0.00026	0.00005	0.00006	5	6	1	1
8	90.0	2.6	7.4	0.00046	0.00038	0.00005	0.00006	11	9	1	1
9	87.4	5.1	7.5	0.00036	0.00054	—	0.00005	9	13	—	1
11	95.0	—	5.0	0.00043	0.00038	0.00006	0.00006	10	9	1	1
12	93.3	1.0	5.7	0.00045	0.00046	0.00007	0.00008	11	11	2	2
18	94.9	2.6	2.5	0.00077	0.00090	0.00006	0.00006	18	21	1	1
22	99.0	—	1.0	0.00196	0.00163	—	—	46	38	—	—
23	97.7	1.0	1.3	0.00196	0.00199	—	—	46	47	—	—
24	93.5	5.1	1.4	0.00220	0.00204	—	—	51	48	—	—
25	88.2	9.9	1.3	0.00108	0.00101	—	—	26	24	—	—
26	99.0	1.0	—	0.00185	0.00192	—	—	43	43	—	—
28	94.9	5.1	—	0.00208	0.00155	—	—	48	36	—	—
29	90.1	9.9	—	0.00181	0.00116	—	—	42	27	—	—

TABLE IV.—*Tensile Tests. Chill Castings.*

No.	Composition.			Tons Stress. Yield-Point. per Sq. In.	Maximum Stress. Tons per Sq. In.	Elongation. Per Cent. on 2 In.	Reduction of Area. Per Cent.	Remarks.
	Copper. Per Cent.	Tin. Per Cent.	Aluminium. Per Cent.					
1 C	88.47	1.18	10.35	15.4	30.20	4.4	5.6	Fracture grey-brown, radially crystalline. Surface smooth.
2 C	91.24	1.06	7.70	9.6	19.64	22.0	24.2	Fracture dull gold, radially crystalline. Surface wavy.
3 C	89.66	2.36	7.98	14.0	29.88	25.0	27.0	Fracture brownish gold, granular. Surface slightly wavy.
4 C	93.58	0.94	5.48	6.2	18.97	54.0	46.7	Fracture pale gold, fine granular to silky. Surface very wavy.
5 C	91.64	2.60	5.76	7.2	16.76	19.2	23.2	Fracture pale gold, granular. Surface wavy.
6 C	89.51	4.93	5.56	9.5	14.98	2.6	3.6	Fracture grey, showing yellow specks, finely granular. Surface smooth.
7 C	90.20	7.41	2.39	9.6	14.61	3.8	3.8	Fracture greyish-brown, showing yellow specks, granular. Surface smooth.

TABLE V.—*Tensile Tests. Annealed Castings.*

No.	Composition.			Tons Stress. Yield-Point. per Sq. In.	Maximum Stress. Tons per Sq. In.	Elongation per Cent. on 2 In.	Reduction of Area. Per Cent.	Remarks.
	Copper. Per Cent.	Tin. Per Cent.	Aluminium. Per Cent.					
1 C A	88.47	1.18	10.35	14.5	29.32	11.9	15.2	Fracture grey-brown, crystalline. Surface smooth.
2 C A	91.24	1.06	7 70	7.4	21.20	68.1	46.4	Fracture dull gold, finely granular. Surface wavy.
3 C A	89.66	2.36	7.98	8.8	27.32	35.8	31.8	Fracture brownish gold, finely granular. Surface frosted and slightly wavy.
4 C A	93.58	0.94	5.48	5.6	17.20	43.5	41.2	Fracture pale gold, silky. Surface wavy.
5 C A	91.64	2.60	5.76	6.8	17.34	33.1	31.6	Fracture pale gold, granular to silky. Surface wavy.
6 C A	89.51	4.93	5.56	9.3	15.61	11.7	12 3	Fracture uniform, grey-brown, granular. Surface slightly wavy.
7 C A	90.20	7.41	2.39	7.8	12.85	9.9	8.7	Fracture uniform, brownish, granular. Surface slightly wavy.

Numbers 1 to 5 inclusive were annealed for 20 minutes at 750 deg. Cent. and slowly cooled in the muffle. Numbers 6 and 7 were treated similarly at 700 deg. Cent.

TABLE VI.—*Tensile Tests. Effect of Replacing Tin by Aluminium.*

No.	Composition.			Chill Castings.		Annealed Castings.		
	Copper per Cent.	Tin per Cent.	Aluminium per Cent.	Maximum Stress. Tons per Sq. In.	Elongation per Cent. on 2 In.	Temperature of Annealing. Deg. Cent.	Maximum Stress. Tons per Sq. In.	Elongation per Cent. on 2 In.
*	90.10	—	9.90	36.93	30.5	800	26.40	5.0
3	89.66	2.36	7.98	29.88	25.0	750	27.32	35.8
6	89.51	4.93	5.56	14 98	2.6	700	15.61	11.7
7	90.20	7.41	2.39	14.61	3.8	700	12 85	9.9
†	Admiralty gun-metal			16.5	15.0	700	21.4	40.0

* Carpenter and Edwards, Proceedings of the Institution of Mechanical Engineers, 1907, page 153; ENGINEERING, Jan. 25, 1907.
† H. S. and J. S. G. Primrose, Journal of the Institute of Metals, 1913, No. 1, vol. ix., page 168; ENGINEERING, April 18, 1913.

TABLE VII.—*Hardness Tests.*

No.	Composition.			Hardness Number.				
				Scleroscope.			Brinell. Load, 3000 Kg.	
	Copper per Cent.	Tin per Cent.	Aluminium per Cent.	Cast.	Annealed.	Quenched.	Cast.	Annealed.
1	88.47	1.18	10.35	32	26	43	189	145
2	91.24	1.06	7.70	11	9	11	81	62
3	89.66	2.36	7.98	16	15	16	102	94
4	93.58	0.94	5.48	8	8	9	62	66
5	91.64	2.60	5.76	11	10	11	78	69
6	89.51	4.93	5.56	19	15	15	120	91
7	90.20	7.41	2.39	18	15	15	114	94

* For details, see Journal of the Institute of Metals, 1913, No. 2, vol. x., page 360.

THE COMPOSITION OF THE EXHAUST FROM LIQUID-FUEL ENGINES.*

By Second-Lieut. ROBERT W. FENNING, R.E. (T.), B.Sc., D.I.C., of London.

(*Concluded from page* 292.)

Air-Petrol Mixtures.—Reference should first be made to Table II. (page 289 *ante*) and Fig. 4, giving the results of the explosion-vessel experiments. The complete combustion mixture is about 15.15; but since the composition of the fuel is not known, the value cannot be checked by direct calculation, and for the same reason the composition of the exhaust products from weak mixtures cannot be computed. The air-petrol ratio has, however, been calculated from the composition of the exhaust for both strong and weak mixtures, as in the case of hexane, and the volume ratio of hydrogen to carbon in the products has been determined, the results being set out in columns 19 and 20 of Table II.

A comparison of columns 2 and 19 of this table indicates that the products appear to contain the constituents of a somewhat stronger mixture than that measured, and it can therefore be concluded that the analysis has revealed practically all the constituents in the exhaust containing any carbon or hydrogen. Under ideal conditions the figures in column 20, showing the ratio by volume of hydrogen to carbon in the products, would be constant and equal to the ratio of the same constituents in the petrol.

The hexane and petrol charts, Fig. 3, page 291 *ante*, and Fig. 4, page 337, are very similar, and the same remarks as to the nature of the exhaust apply to both.

Mr. H. Ballantyne, F.I.C., F.C.S., in a contribution† presented about seven years ago, stated that he had found the following relation to exist between the carbon monoxide, hydrogen, and methane in exhaust gases from petrol-engines:—

$$H_2 = 0.36\ CO.$$
$$CH_4 = 0.12\ CO.$$

This relation of H_2 to CO has been plotted in Figs. 4 and 5, and is shown by a dot-and-dash line. It will be observed that Mr. Ballantyne's curve and the author's are in fair agreement up to a mixture strength of 12, beyond which it is possible that Mr. Ballantyne did not go, since the divergence becomes marked for strong mixtures. The practical absence of CH_4 in the author's analysis does not, however, support Mr. Ballantyne's relation.

Turning to Table III., page 290 *ante*, and Fig. 4, the engine-exhaust samples can be considered. The remainder of the fuel (sample A) used in the explosion vessel experiments was soon consumed in the engine tests, and other samples (B and C) of "Bowley Special" had to be employed. In all the engine-exhaust samples readings were taken of the air and fuel, for the purpose of a direct computation of the mixture strength. Owing probably to a leakage in the carburettor valve, this object was defeated in samples 268 to 277. The mixture strength for these samples has therefore been estimated from the explosion-vessel exhaust-gas chart, Fig. 4. This chart has been reproduced by full-lines in Fig. 5, and vertical dot-and-dash lines A, B, C, &c., have been drawn at the estimated mixture strengths, thus permitting a rapid comparison between the actual values of the analysis set out in Table III. and those given by the estimated mixture from the chart.

The hydrogen values did not agree with those of the explosion-vessel tests nearly so well as those for CO_2, CO, and O_2, and therefore the latter were used for fixing the positions of the mixture-strength lines A, B, C, &c., whilst the engine-exhaust values of the hydrogen were plotted on these lines. A new hydrogen curve was thus obtained for the engine exhaust; it is shown by a dotted line, and is somewhat above the explosion-vessel curve. The first part of this new curve agrees very closely with Ballantyne's. Note that in using the exhaust-gas chart for estimating mixture strength the CO_2, O_2, and CO curves only are necessary, and a short analysis is all that is required. To have abandoned the engine tests at this point would, however, have left in doubt the agreement between the composition of the exhaust from the explosion vessel and from the engine, using the same strength of mixture. The carburettor defect having been remedied, further engine tests were run, yielding samples 278 to 283. These samples were analysed for CO_2, O_2, and CO, and the results, neglecting any slight engine leakage, plotted in Fig. 5, according to the mixture strength as measured to the engine. The points, surrounded by a circle, are shown close to the CO_2, O_2, and CO curves. Their agreement with these curves illustrate the striking

* Paper read before the Institution of Mechanical Engineers, March 17, 1916.
† Proceedings of the Institution of Automobile Engineers, vol. ii, page 101, 1908-09.

similarity in the products from the explosion vessel and the engine, and also the accuracy of Dr. Watson's apparatus for measuring the air and fuel supplied to the engine.

Referring to Table III. (page 290 *ante*), columns 5 and 7, the presence of O_2 and CO in the same engine-exhaust sample needs some comment. The statement that combustible gases and oxygen should not exist in the same sample is supported by the explosion-vessel tests. How, then, is the presence of the oxygen in the engine samples to be explained? It is probably due to leakage past the sleeves during the compression, for much of such leakage would find its way into the exhaust. If leakage is the explanation, then the amount of oxygen represents only the oxygen constituent of the leakage, and the actual charge lost is about five times this amount.

What becomes of the small quantity of petrol vapour thus introduced into the exhaust? No doubt it partly accounts for the CO_2 in column 9. Columns 9 and 12 should agree for the same mixture. In the analysis of which column 9 is a part, however, it will be observed that the heavy hydrocarbons have not been estimated—that is, fuming sulphuric acid has not been used. Although this acid is not considered to be an absorbent for saturated hydrocarbons, such as petrol, it has been found experimentally by the author that a mixture passed into fuming sulphuric acid has the greater part of the petrol

Fig. 4. PETROL "EXHAUST-GAS CHART." EXPLOSION-VESSEL TESTS.

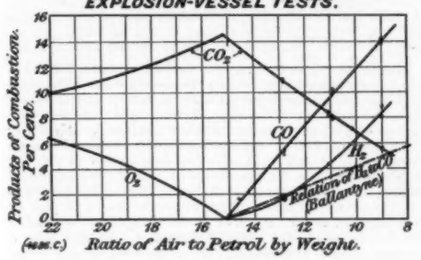


Fig. 5. PETROL "EXHAUST-GAS CHART" AS IN FIG. 4, WITH ENGINE-EXHAUST POINTS ADDED.

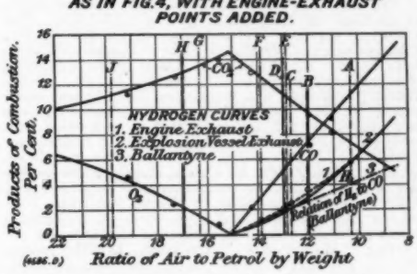


Fig. 6. BENZENE "EXHAUST-GAS CHART." EXPLOSION-VESSEL TESTS.

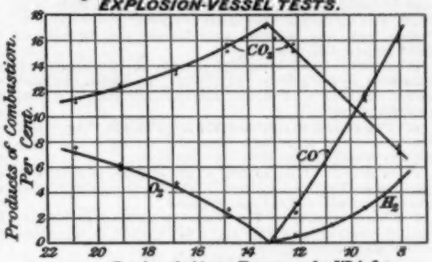


Fig. 7. BENZENE "EXHAUST-GAS CHART" AS IN FIG. 6, WITH BENZOL ENGINE EXHAUST POINTS ADDED.

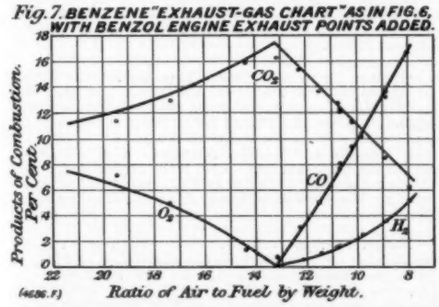


Fig. 8. RELATION OF H_2 TO CO IN 100 VOLUMES OF PRODUCTS OF COMBUSTION.

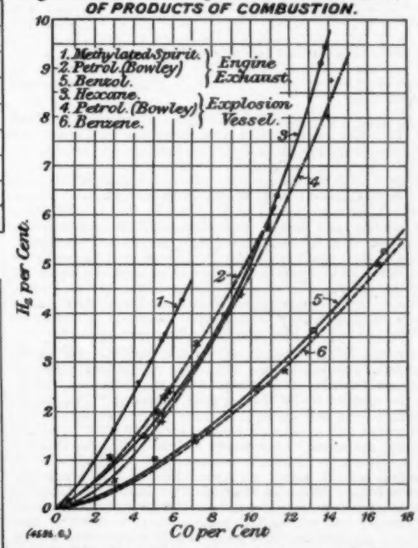
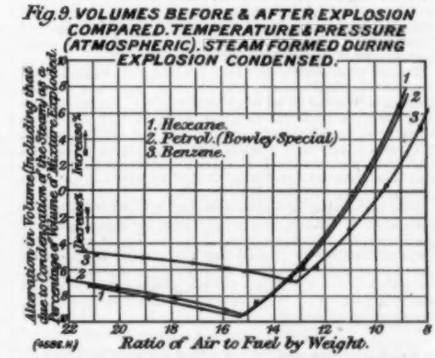


Fig. 9. VOLUMES BEFORE & AFTER EXPLOSION COMPARED. TEMPERATURE & PRESSURE (ATMOSPHERIC). STEAM FORMED DURING EXPLOSION CONDENSED.



removed. Some of the discrepancy between columns 9 and 12 is thus explained, and support is given to the suggestion of a small engine leakage. No allowance in the percentage of products or in volume of O_2 in weak mixtures has been made for such leakage when comparing with explosion-vessel tests.

Further, columns 18 and 19, Table III., have been calculated irrespective of this slight leakage, the unsaturated hydrocarbons, where determined, being taken as C_2H_4. Taking account of the leakage would raise the percentage (for comparison with explosion-vessel tests) of CO_2, lower that of O_2, raise that of CO and H_2, increase the ratio of hydrogen to carbon in the exhaust, and give a stronger calculated mixture strength. The amount of petrol vapour in the exhaust is, of course, small, and if inserted in the analysis would probably vary from 0.03 to 0.07 per cent.

It would be appropriate to point out at this stage that the author has found from a number of experiments that when a mixture of air and hexane is passed successively into pipettes containing caustic potash, alkaline solution of pyrogallol, and acid solution of cuprous chloride, as in the partial analysis of exhaust products, the mixture loses strength slightly, showing that some hexane vapour is absorbed.

Air-Benzene and Air-Benzol Mixtures.—A series of experiments on air-benzol mixtures, using the explosion vessel, was first carried out. The results, when plotted, supported one another excellently, but engine-exhaust samples showed that the whole chart required moving to the left, and the complete combustion point given by the curve—namely, 12.7—illustrated the same requirement. Was it possible that one or more of the benzol constituents did not evaporate completely? Commercial benzol usually contains benzene, toluene, and a small quantity of xylene, of which the first evaporates readily, the second without difficulty, but the third is far from volatile. The actual composition of the benzol used in these tests has not at present been determined. Suggestions of making up a mixture in known proportions of these three constituents, and of using pure benzene, were adopted.

The fuel mixture contained 64.3 per cent. benzene, 27.7 per cent. toluene, and 8 per cent. xylene, giving an air-fuel ratio for complete combustion of about 13.37. An air-fuel mixture having a ratio of 13.36 was then prepared and its products of combustion analysed. The analysis indicated zero CO and over 1 per cent. of O_2, instead of zero CO and zero O_2, showing that the fuel mixture became weakened, due to incomplete evaporation of the fuel or some other cause. The xylene constituent was very heavy in this case.

These experiments and others led to the conclusion that benzol was unsuitable for use with the explosion vessel, and a set of experiments with benzene was put in hand. The results of the benzene explosion-vessel experiments are given in Table IV. (page 290 *ante*) and Fig. 6. It will be observed that in this case the volume of mixture exploded appeared to have a marked effect on the composition of the products, the smaller volume seeming to be weaker than the larger. Preference was given to the larger volume points when drawing the exhaust-gas chart. Further, in plotting "the alteration in volume curve," Fig. 9 (below), in which the readings depend on the small volume explosions, the strength of mixture was estimated from the exhaust-gas chart already drawn, and not from the measured values. The figures for the check analysis, columns 15, 16, 17 and 18, are not in such good agreement as in the other cases, and here the hydrocarbons have been taken as C_2H_6. Methane seems to be entirely absent and heavy hydrocarbons are practically non-existent.

Comparing the calculated and experimental compositions of the products from weak mixtures—as in the case of hexane—the same discrepancies as in the hexane are found:—

Air / Benzene by Weight.	CO_2 per Cent.		O_2 per Cent.		Contraction in Volume per Cent.	
	Experimental.	Calculated.	Experimental.	Calculated.	Experimental.	Calculated.
15	15.4	15.4	2.45	2.6	6.1	6.0
17	13.65	13.5	4.5	4.7	5.5	5.3
19	12.35	12.0	6.05	6.4	5.0	4.8
21	11.35	10.85	7.25	7.9	4.05	4.35

Columns 19 and 20, Table IV., have been calculated as in previous cases, except that the heavy hydrocarbons have been taken as C_6H_6 instead of C_2H_4. With strong mixtures the mixture strength is slightly weaker by calculation than by measurement, whereas with mixtures weaker than 13 the reverse is the case. The volume ratio of hydrogen to carbon in the fuel (C_6H_6) is 1 to 1, and this is fairly well maintained in the exhaust products, column 20, although there is slight excess of hydrogen or deficiency of carbon, as in the hexane results.

It is of interest to note that the products of the strongest mixture, 8.07, contained sufficient combustible gases to explode a second time after the addition of oxygen, no electrolytic gas being required.

Table V., page 291 *ante*, contains the results from the engine tests using commercial benzol. In Fig. 7 the curves are a reproduction of the benzene exhaust-gas chart, Fig. 6, but the points are those obtained from the benzol-engine tests only, the benzene points having been omitted. On the whole there is a marked agreement, especially in the CO and H_2 curves. In this case, therefore, the benzene exhaust-gas chart could be applied to determine mixture strength from benzol exhaust without much error. The explanation of the presence of O_2 in the products of strong mixtures has already been given in connection with the engine tests using petrol.

The engine leakage has not been allowed for, when determining the percentage of the constituents in the exhaust, nor has any account been taken of it when computing the ratio of air to benzol from the composition of the exhaust, except to consider the hydrocarbons, where determined, to consist of C_6H_6. The calculated mixture strengths, column 13, are in very fair agreement with the measured strengths, column 2, although in most cases the calculated strength is the weaker. Had engine leakage been allowed for, the calculation would have given a stronger mixture in those cases in which the heavy hydrocarbons were not determined.

Relation of Hydrogen to Carbon Monoxide.—In Fig. 8, annexed, the relation of H_2 to CO is shown graphically. In comparing the products of the engine tests and the explosion-vessel tests, curves 2 and 4 for petrol should be examined. It will be observed that the ratio of H_2 to CO is greater in the engine exhaust than in the explosion-vessel exhaust. The increase in the volume of H_2 is clearly shown in the exhaust-gas chart, Fig. 5 (above).

The methylated spirit readings, curve 1, were plotted from the following values, taken from the analysis of several samples of engine-exhaust gases:—

H_2	1.65	2.55	3.0	3.40	3.55	4.25
CO	3.0	4.20	4.8	5.45	5.6	6.50

With this fuel also practically no methane was found in the products.

The equations of the curves are:—

Curve 1, methylated spirit, engine exhaust:—

$$H_2 = \frac{1}{2.37} CO^{1.24}.$$

Curve 2, petrol (Bowley Special), engine exhaust:—

$$H_2 = \frac{1}{4.62} CO^{1.56}.$$

Curve 4, petrol (Bowley Special), explosion-vessel exhaust:—

$$H_2 = \frac{1}{8.43} CO^{1.61}.$$

Curve 5, benzol, engine exhaust:—

$$H_2 = \frac{1}{12.47} CO^{1.45}.$$

Curve 6, benzene, explosion-vessel exhaust:—

$$H_2 = \frac{1}{14.89} CO^{1.33}.$$

The curves drawn in Fig. 8 are those of the equations

given. Curve 3, however, has been drawn through the points irrespective of any mathematical relation.

Alteration in Volume Due to Explosion of Air-Fuel Mixture.—In dealing with this change in volume, it must first be noted that the volume after explosion was measured at atmospheric temperature. This means that the steam formed by the combustion of H_2 was condensed before volume measurements were made. Therefore the curves in Fig. 9 do not represent the change in volume due to combustion that would take place in the working fluid of an internal-combustion engine. The greatest contraction in volume, under the given conditions of measurement, occurs at the point of complete combustion. Bearing this in mind, the complete combustion points given by Fig. 9, and by the exhaust-gas charts, compare very favourably.

The method of correcting the strength of mixture before plotting curve 3 has already been mentioned; that for computing the contraction in volume has been set out on page 291 *ante*. The tables on pages 291 and 337 indicate that the experimental contractions for weak mixtures are somewhat greater than the calculated.

Conclusion.—From the foregoing experiments it can be concluded that:—

(*a*) With volatile fuels there is but little difference in the composition of the products of combustion resulting from air-fuel mixtures in a small explosion vessel or in an engine cylinder, in spite of the conditions being so dissimilar. In fact, the agreement between the CO_2, O_2, and CO values in engine and explosion-vessel tests is so close that an exhaust-gas chart prepared from explosion-vessel tests can be used to estimate the strength of mixture supplied to an engine.

(*b*) A very small quantity, if any, of unsaturated or saturated hydrocarbons is present in engine-exhaust gases. Taking a particular instance, methane is almost entirely absent.

(*c*) The hydrogen constituents in exhausts from strong mixtures is an important item, and increases in value rapidly with increase in mixture strength.

(*d*) The ratio of air to fuel in the original mixture can be calculated with a considerable degree of accuracy from the composition of the exhaust gases.

(*e*) The reliability of Dr. Watson's method and apparatus for measuring the air and fuel supplied to an engine is once more demonstrated.

Since one of the fuels used in the explosion-vessel tests—viz., Bowley's Special petrol, is a commercial motor spirit, it is hoped that the exhaust-gas chart for the fuel will prove useful in engine-testing, both for estimating the mixture strength and for determining the waste of heat due to incomplete combustion. The benzene chart may also be applicable in many cases.

It has been shown by Dr. Watson and others that mixture strength has a considerable influence on the thermal efficiency of an explosion engine. Given an exhaust-gas chart for the fuel, the strength of mixture can readily be found from an analysis of the exhaust gases. Why not adopt this method when setting carburettors, and thus promote fuel economy, lessen carbonisation, and minimise the pollution of the atmosphere by such poisonous gases as carbon monoxide?

The author has already expressed his great indebtedness to Dr. Watson, and would now acknowledge with gratitude the facilities given by the Governors of the Imperial College of Science and Technology for carrying out the experiments. To many others his thanks are due, including Dr. J. C. Philip for suggestions regarding the analysis, and Mr. J. Wilson for assistance in taking the engine-exhaust samples.

An Alloy for Rolls.—An iron alloy which will produce cast chilled rolls or sand rolls having a very hard surface, with a strong central portion, is covered, says the *Iron Age*, by a patent (U.S. 1,166,342, December 28, 1915) granted to H. E. Field and F. C. Daniels, of Wheeling, W. Va. The range in composition is thus stated: Silicon, 0.25 to 1.50 per cent.; sulphur, 0.025 to 0.20 per cent.; phosphorus, 0.010 to 1 per cent.; manganese, 1.50 to 3.50 per cent.; carbon, 1.50 to 3.50 per cent. The rolls cannot be machine-finished except with grinding-machines. The surface hardness does not lessen with use, and the rolled material has a bright, smooth-finished surface.

Water-Power in Norway.—The city of Christiania has purchased the falls in the Halsvasdrag for an aggregate sum of 38,000*l*. The rights comprise the main falls from Strandefjord down to Villans Bridge, with a net head of 295 metres; the Djupdal Fall, between Hövafjord and Halsfjord, with a head of about 50 metres; and, further, the Mölndal Falls, from Halsfjord to the river, and joining the Hallingdal River, with a head of about 70 metres. The aggregate capacity of these falls is estimated at 70,000 horse-power at the primary stations and at 46,000 kw. at the city boundary. This result is based upon a calculated volume of water of 16 cub. m. per second in the main fall, 17.3 cub. m. per second in the Djupdal Falls, and 17.6 cub. m. per second in the Mölndal Falls. The transmission has to take place over a distance of some 125 miles, at a voltage of 100,000 volts; such a high voltage has not as yet been used in Norway. Two experts, reckoning upon a larger volume of water, 24 cub. m. per second, have put the capacity at 100,000 horse-power. The complete cost of exploitation has been calculated at 1,940,000*l*., which comes out at about 40*l*. 10*s*. per kilowatt at the city boundary, when all three falls are utilised. The annual cost per kilowatt when only the main fall is turned to account will be 4*l*. 13*s*. The corporation at present pays the Kykkelsrud station 3*l*. 18*s*. per kilowatt for the first 2000 kw., and 3*l*. 11*s*. per kilowatt per annum for the rest.

COLONIAL AND FOREIGN ENGINEERING PROJECTS.

We give below a few data on several colonial and foreign engineering projects, taken from the *Board of Trade Journal*. Further information on these projects can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, London, E.C.

Australia: The Sydney Office of H.M. Trade Commissioner for Australia reports that the New South Wales Minister of Agriculture has recently entered into an agreement with a firm of engineers for the supply of plans and specifications for elevators for the bulk handling of grain in the State. It is anticipated that the preparation of these plans will take some months, and that the first building to be erected—namely, the Sydney terminal elevator—will be undertaken about next August. New South Wales will thus be the first State in the Commonwealth to adopt the system of handling grain in bulk by elevators. Eventually all the States will, no doubt, adopt the bulk-handling system on the lines of that followed in Canada. Victoria and South Australia are also moving in this direction, and it is probable that definite plans will be formulated in both States in the course of the next few months.

South Africa: H.M. Acting Trade Commissioner has forwarded a copy of the Estimates of Expenditure of the South African Railways and Harbours for the year ending March 31, 1917. Railways: The total estimated expenditure on railways is put at 12,561,101*l*. The following expenses are assigned under the heading "Maintenance of Permanent Way:" Sleepers, 86,782*l*.; rails, 50,101*l*.; other material, 22,494*l*.; bridges, 24,005*l*.; crossings, overhead bridges, fences, &c., 14,137*l*.; signals, 27,568*l*.; telegraphs and telephones, 53,370*l*.; and water supply, 23,283*l*. As regards material for the maintenance of rolling-stock, 297,742*l*. is allotted in connection with locomotives, 96,598*l*. for coaching stock, and 218,590*l*. for goods stock; 39,777*l*. is assigned for expenditure on lubricating supplies, 20,562*l*. for running stores for locomotives and vehicles, 14,300*l*. for maintenance of tarpaulins, and 8000*l*. for creosote required by sleeper factories. Harbours: The total estimated expenditure on harbours is put at 1,175,926*l*. The following sums appear under the heading "Maintenance:" Dredging, 43,864*l*.; jetties, wharves, and quays, 14,721*l*.; breakwaters and sea-walls, 5540*l*.; buildings, &c., 19,893*l*. According to information received at the office of H.M. Trade Commissioner in South Africa, from the Commissioner of Customs and Excise at Pretoria, it has been decided by the Administration of the South African Railways to provide a new erecting-shop at Salt River, near to Cape Town, at a cost of approximately 23,000*l*. This will enable the heavier type of locomotive now in use to be handled with greater expedition.

Canada: According to telegraphic information received at the office of the High Commissioner in London for Canada, from the Minister of the Interior at Ottawa, the contractors for the Quebec Government are preparing to proceed with the construction of a dam on the St. Maurice River in Quebec Province, preliminary work having been started last summer. The St. Maurice River is 440 miles in length, and has a watershed of 2700 square miles. The dam is to be constructed 225 miles from the confluence of this stream with the St. Lawrence River at Three Rivers, and will create a reservoir of approximately 300 square miles. The manufacturing towns of La Tuque, Grand 'Mère, Shawinigan Falls and Three Rivers have been built up largely through the utilisation of the water powers of the St. Maurice River for paper-mills, &c.

Spain: H.M. Consul at Seville reports the publication of a Royal Decree approving the general plans for the construction of a bridge over the Guadiaro River, in the district of La Linea, near Gibraltar. The length of the bridge will be approximately 300 metres, and the estimated cost of its construction about 22,000*l*. Tenders for the execution of the works will be called for shortly. The *Gaceta de Madrid* notifies that tenders will be opened, at 11 a.m., on April 15, by the Municipal authorities of Mota del Marqués (Province of Valladolid), for the construction of a new school at that town, at an estimated cost of 81,531 pesetas (about 3260*l*.). The *Gaceta* also notifies that tenders will be received, within a period of thirty days from March 13, by the Municipal authorities of San Feliu de Guixols (Province of Gerona), for a concession for the public lighting of that town, either by gas or electricity. The *Gaceta* further notifies that tenders will be opened, at noon on May 19, at the Dirección General de Obras Públicas, Ministerio de Fomento, Madrid, for the construction and working, for a period of sixty years, of an electric tramway in Bilbao, connecting the existing system with the Iralа-Barri district. The minimum rolling-stock required to commence the working of the line is one motor and one trailer-coach for passengers, and one motor goods coach and two trailer goods wagons. Construction work must be commenced within three months and completed within eighteen months from the date of the award of the concession. An option on the concession is held by the Sociedad Tranvia Urbano de Bilbao. The *Gaceta* also notifies that tenders will be opened, on April 29, at the Casa Consistorial, Plaza de la Villa, No. 4, Madrid, for the construction and maintenance of basalt pavements in the streets of the capital. The period allowed under the contract for the construction of new pavements will be from the date of the adjudication until December 31, 1920, and the period for keeping the pavements in good repair will terminate at the end of 1924.

Brazil: H.M. Consul at Porto Alegre reports that the Public Works Department (Directorate of Land Ways) of the State of Rio Grand do Sul has issued a call for tenders for the construction of a section of the railway from Carlos Barbosa to Bento Gonçalves, a distance of 5080 metres, estimated to cost 17,500*l*. Tenders were to be received by March 4. The work to be carried out includes the clearing of the forest and undergrowth, &c., the laying of the permanent way, the erection of a telephone line, buildings, &c. The State Government will supply the rails, fish-plates, switches, &c., in fact all that is necessary, including the metal superstructure for a bridge over the Marrecão stream. The State will also hire to the contractor the rolling-stock necessary for the carrying out of the contract. It is suggested that this information may be of interest to United Kingdom manufacturers who might possibly be able to supply plant and materials for railway construction, &c., to the State Government.

Uruguay: The *Diario Oficial*, Monte Video, publishes a Resolution of the Uruguayan Ministry of Industries authorising further studies to be made in connection with the projected irrigation of the Mataojo district, in the Department of Minas. The Agronomical Laboratory of Sayago will make investigations regarding the agricultural possibilities of the zone.

Bolivia: With reference to the Decree authorising the Bolivian Executive to call for tenders for the construction of a railway from Potosi to Sucre, H.M. Legation at La Paz reports that a Decree, dated January 5, has now been issued calling for tenders, up to June 30, for the construction and working of the proposed railway. Article 8 of the Decree provides for the admission into Bolivia, free of customs duties, of the material, machinery, and tools required for the projected railway.

Argentina: The *Boletin Oficial*, Buenos Aires, publishes a Decree approving a project prepared by the Ministerio de Relaciones Exteriores y Culto relative to the construction of a hospital in Posadas (Misiones), at an estimated cost of 346,681 pesos currency (about 30,300*l*.). A further Decree, published in the *Boletin*, authorises the Comisión Asesora de Asilos y Hospitales Regionales to call for public tenders for the execution of the above-mentioned works. The *Boletin* also contains a Decree approving a project drawn up by the Government of the Province of Santiago del Estero, relative to an irrigation canal from the Río Salado to the town of Añatuya. It publishes a further Decree authorising the Dirección de las Obras Sanitarias to carry out the necessary works for the supply of drinking water in certain quarters of the town of Córdoba, at an estimated cost of 52,783 pesos currency (about 4600*l*.).

Gold.—The value of the gold imported into the United Kingdom in the first two months of this year was 4,705,251*l*., as compared with 866,190*l*. in the corresponding period of 1915, and 6,672,103*l*. in the corresponding period of 1914. In these totals Rhodesia figured for 752,704*l*., nil, and 413,658*l*. respectively; the Transvaal for 2,829,392*l*., nil, and 5,226,126*l*. respectively; and British India for 799,985*l*., 14,975*l*., and 385,487*l*. respectively. The fluctuations observable were, of course, attributable to the war.

Naval Training for Civilians.—The Navy Department, says the New York *Marine Journal*, is planning to start the training cruise for civilians on August 15. Reserve battleships will be detailed and apportioned among the coast districts according to the number of applicants accepted in each. The training course will occupy four weeks, three of which will be spent at sea. Able-bodied American citizens between the ages of 19 and 45 are eligible, and each will have to deposit 30 dols. for subsistence and clothing.

The Public Schools Year-Book, 1916.—This year-book is edited by Mr. H. F. W. Dean, M.A., F.S.A., and Mr. W. A. Bulkeley Evans, M.A., and is published by the Year-Book Press, 31, Museum-street, W.C., at the price of 5*s*. net; the present edition is the twenty-seventh. It opens with an account of the Headmasters' Conference, and gives full information on the various schools. Special chapters deal with entrance scholarships, with the regulations for entrance into the Navy, the Army, the Civil Service, &c., and give information as to the possible future in a large number of other avocations.

Cutlery.—There has been a rally this year in our cutlery exports, the quantity sent abroad in February having been 2552 cwt., as compared with 1800 cwt. in February, 1915, and 3263 cwt. in February, 1914, while for the first two months of this year the aggregate shipments were 5214 cwt., as compared with 4538 cwt. and 7893 cwt. in 1915 and 1914 (corresponding periods). British cutlery shipments to the United States to February 29, this year, amounted to 383 cwt., as compared with 584 cwt. and 1405 cwt. in the first two months of 1915 and 1914 respectively. France took 258 cwt. to February 29, as compared with 28 cwt. and 22 cwt. The Colonial demand, which is the mainstay of our external cutlery business, was as follows in the first two months of the last three years:—

Colonial Group.	1916. Cwt.	1915. Cwt.	1914. Cwt.
South Africa	458	365	571
British India	363	453	908
Australia	1,522	1,143	1,112
New Zealand	365	200	171
Canada	459	493	791

The value of the cutlery exported to February 29, this year, was 102,983*l*., as compared with 82,496*l*. and 124,528*l*. respectively. Upon the whole, the results indicated may be regarded as satisfactory; the explanation, no doubt, is that cutlery wears out, and must be replaced so long as any resources are available for its replacement.

USE OF TAR AND TAR-OILS IN DIESEL ENGINES.

AT the February meeting of the Diesel Engine-Users' Association, the subject of the use of tar and tar-oils as fuels for Diesel engines, referred to on page 214 *ante*, was further discussed, and Mr. W. Batho, of Messrs. Sulzer Brothers, and Mr. L. W. Johnson, of Messrs. Banks, Warner and Co., Limited, were specially asked to attend the meeting in order to express their views. The importance of the subject at the present time is such that the following abstract of their remarks should be of considerable interest.

Mr. Batho, who spoke first, pointed out that in this country the price of mineral oils had been such that there had been little inducement to manufacturers to experiment with tar and tar-oils. The conditions, however, were different on the Continent, and much more attention had therefore been given to the matter by Continental engineers, especially in Germany, where the total production of tar, it had been stated, was sufficient for 5,000,000,000 horse-power. In Switzerland about 140 Diesel engines, ranging from 20 to 1000 horse-power, and giving 24,000 horse-power in the aggregate, had been installed by the speaker's firm, and nearly all these engines were run on tar-oil prior to the outbreak of war. The tar-oil was all imported, and not only did the supply immediately fail, but also the supply of mineral oil, with the result that prices increased enormously, and at one time fuel-oil was almost unobtainable. Fortunately, there was a considerable quantity of vertical-retort tar available, and as Messrs. Sulzer Brothers had carried out experiments with this fuel, and had designed a special method of burning it, they were in a position to help their clients by fitting a number of engines with this arrangement for burning tar. It proved to be of particular service in the construction of the Hauenstein Tunnel on the Swiss Federal Railways, for which purpose two Diesel engines, of 500 horse-power, had to run continuously for two or three weeks at a time, driving compressors with very variable loads. The conditions were thus extremely difficult to meet, but the contractor has reported that the working has been perfectly satisfactory, and the engines are still in excellent condition.

Messrs. Sulzer also found it necessary to take steps to maintain their own supply of fuel, and, for this purpose, they installed a tar-distillation plant of their own design. The plant has proved quite satisfactory, and has been able to supply not only their own requirements, but those of many of their clients as well. Although it would have been possible to utilise ordinary tar, it was deemed advisable to instal a distillation plant, as the tar-oil thus obtained is a cleaner and more satisfactory fuel than ordinary tar. Valuable by-products, such as benzol, toluol, ammoniacal liquor, and anthracene, obtained by distillation, would also be lost by using ordinary tar directly in Diesel engines. A further reason for the course taken was that vertical-retort tar can usually be obtained in small quantities only, and with other qualities of tar distillation is essential. About fifty engines, totalling 30,000 horse-power in units ranging from 20 to 3500 horse-power, have been installed by the firm in France, tar-oil being used as fuel in almost every case. The French Government, however, have now taken over the production of tar in that country, so that tar-oil is practically unobtainable, and Diesel-engine users have had to fall back on gas-oil for fuel. This is a rather curious circumstance in view of the fact that, in England, the question of using tar-oil is being discussed on account of the high price of mineral oils.

Most of Messrs. Sulzer's engines, especially those of the two-stroke-cycle type, run on tar-oil without any auxiliary fuel-pump. Much depends, however, on the conditions under which the engine has to work, and, in some cases, an auxiliary pump, with a pilot jet for ignition purposes, has been fitted. The idea of injecting a small quantity of inflammable oil to assist the ignition of the heavier fuel-oil, the speaker said, was not new, and had, in fact, been mentioned by Dr. Diesel in his original patent. Messrs. Sulzer had found that it was necessary to atomise the ignition oil, and not inject it in what might be described as the "solid" state. Unless this was done, the initial combustion was impaired and the consumption of ignition oil considerably increased.

The speaker then gave some particulars of tar-oils and tars suitable for use in Diesel engines. Almost all the heavy tar-oils, he said, could be used, though in some of them a certain amount of crystallisation occurred after storage in cold weather. The crystals, however, could usually be dissolved quite easily by heating the oil, and this should be done, as they contained elements of high fuel value. The lower calorific value varied from 15,800 to 16,500 B.Th.U. per lb., and the flash-point from 70 deg. to 130 deg. Fahr.; from the point of view of safety against fire it was, however, undesirable to employ oils with flash-points lower than 100 deg. Fahr. Tar-oils were all very fluid and the viscosity was seldom greater than 2 deg. Engler; the specific gravity should be between 1.0 and 1.1. When dropped on white paper the oil should spread without leaving any black residue, the presence of which would indicate a large percentage of free carbon or other tar ingredients. These residues only began to vaporise at about 400 deg. Cent., and would lead to a considerable amount of deposit in the engine cylinders and necessitate the frequent cleaning and grinding in of the exhaust-valves. The amount of ash or water present should not exceed 1 per cent. in either case, and the sulphur content might be from 0.5 to 1 per cent. With regard to tars, those produced from lignite or gas-oil were most suitable, but the quantity available was so small that they were scarcely worth considering. With gas-tar the most important point was the contents of asphalt and pitch. Vertical-retort tar could be used without difficulty with ignition oil supplied by an auxiliary fuel-pump, and specially prepared lubricating oil had also to be employed. Tars from horizontal and inclined retorts were not suitable for direct use in Diesel engines, and it was therefore necessary to distil them for the tar-oil; coke-oven tars should also be treated in this way. The specific gravities of coal tar, lignite tar, and gas-oil tar were given as 1.06 to 1.12, 0.95 to 1, and 1.03 to 1.07 respectively. Tars with a calorific value of less than 15,500 B.Th.U. per lb. were of little use, and those with a very high viscosity, say over 20 deg. Engler at 20 deg. Cent., were unsuitable for good combustion. With regard to flash-point and water contents, the remarks made in connection with tar-oil might also be applied to tar; and it should be borne in mind, in this connection, that certain inconveniences attending the use of tar would be considerably increased if the amount of water present in the tar were large. The ash content should not exceed 0.1 per cent., and a thin layer of the tar poured on to glass or paper should show the smallest possible quantity of black or crystallised deposits.

Mr. Johnson, who spoke next, said that in Germany some 850,000 horse-power was developed by Diesel engines, and of this amount about 150,000 horse-power was produced from tar or tar-oils; the corresponding figures for this country were 80,000 and 1000 horse-power respectively. The fact that the lowest import duty on petroleum oils in Germany was 36s. a ton had greatly encouraged the use of the home product. In consequence of this taxation, tar-oil had proved cheaper to use than even Galician fuel, notwithstanding the facts that the calorific value of tar-oil is 10 per cent. lower than that of gas-oil, and the consumption of tar-oil is 10 per cent. higher. In Great Britain about 11,000,000 horse-power were used for industrial purposes, about 10,000,000 horse-power being developed in steam-engines. Assuming 6 lb. of coal per indicated horse-power hour, and taking the working hours as 2500 per annum, this would require 67,000,000 tons of coal, costing 50,000,000*l.* at 15s. per ton. With the internal-combustion engine the corresponding power would be represented by 9,500,000 horse-power, which would require 6,500,000 tons of oil, taking the consumption as 0.6 lb. per brake-horse-power hour. With oil at 3*l.* per ton the total cost would be 19,500,000*l.*, so that a saving of some 30,000,000*l.* would be effected annually by the use of oil. The national wealth would also be increased by subjecting the coal to a distillation process, its value being increased by fully 75 per cent. in this way.

It was necessary to consider, the speaker continued, what was the total quantity of tar-oil available, its market value, and how the latter would be affected if this fuel came into general use. The first point, however, could not be usefully considered at the present time. With regard to the second question, tar-oils had so far been used chiefly for creosoting timber, and most of the available supplies were now sent to the United States. In 1913, 40 per cent. of our total production of tar was exported to America, the amount being approximately 200,000 tons, which would provide nearly 250,000 brake horse-power, working 3600 hours per annum. A further large percentage was exported to Germany, and this now also went to the United States. A number of tar-distilling plants had, however, recently been installed in America, and this fact was of considerable importance in view of our large export trade to that country. The speaker stated that he had recently approached some fifty firms in this country in the matter of obtaining supplies of tar-oils, and, of this number, only about a dozen had been able to make any offers. Only about half of the latter were able to supply products suitable for use in Diesel engines, and the total quantity from these sources would only amount to from 5000 to 8000 tons per annum; the prices quoted ranged from 2*l.* 10s. to 7*l.* per ton. Further information had, however, been received, from which it seemed that an additional million gallons per annum could be supplied from other sources.

Continuing, Mr. Johnson stated that Continental engineers had given considerable attention to the question of using suitable tar-oils in existing Diesel engines without making costly modifications in design. In 1909 Messrs. Körting Brothers, the M.A.N. Co., and Messrs. Sulzer Brothers had succeeded in burning tar obtained from the gasification of English, Westphalian, and Silesian coals. In most cases, however, pilot ignition had been resorted to, and only quite recently had any measure of success attended the efforts made to use this fuel without pilot ignition. The chief difficulties occurred at loads less than three-fourths of the full load, the temperature in the cylinder at the time of opening the fuel valve then being insufficient to start and complete the combustion of the charge. The speaker knew of an engine of 150 horse-power which had been running for about three years with ordinary gas works' tar, using pilot ignition, and giving absolute satisfaction. Several others were running successfully on distilled tar without pilot ignition. Of the many different methods tried for burning tar-oil only two appeared to be practicable—viz., the modification of the design of the fuel-valve and the use of pilot ignition. Of these, the former seemed to be the correct one, but the latter had become the standard practice. What appeared to be required, in the speaker's opinion, was that a small quantity of tar-oil should enter the cylinder before the main charge, this small quantity then being readily converted into the gaseous form, and serving to raise the temperature sufficiently to ensure the easy and complete combustion of the main charge. In conclusion, Mr. Johnson gave some data of oil consumption of engines at various loads using tar-oil with and without pilot ignition. With a 100-horse-power engine using tar-oil of a calorific value of 15,300 B.Th.U. per pound, the fuel consumption per brake-horse-power hour at full load, three-quarters load, and half load was 0.47 lb., 0.44 lb., and 0.42 lb., with 0.008 lb., 0.034 lb., and 0.05 lb. of ignition oil at the respective loads. Without ignition oil a 400-horse-power engine consumed 0.43 lb., 0.44 lb., and 0.47 lb. of tar-oil per brake-horse-power hour at full load, three-quarters load, and half load respectively, the fuel in this case having a calorific value of 16,300 B.Th.U. per pound.

In the discussion which followed, much stress was laid on the advantage which would accrue to British users of Diesel engines if, in the future, they were not entirely dependent on the use of imported petroleum fuel oils. The importance of the matter from a national standpoint, particularly in reference to the more economical utilisation of the mineral resources of the country, was also referred to.

METALLIC PERMANENT-WAY.—In common with practically every other branch of public enterprise, our exports of metallic permanent-way material have suffered from the depressing influences of the great war. The shipments in February were only 925 tons, as compared with 5000 tons in February, 1915, and 4282 tons in February, 1914. The aggregate shipments for the first two months of this year were 1879 tons, as compared with 9199 tons and 14,743 tons. The deliveries to British India were only 522 tons, as compared with 7264 tons and 8575 tons; but South Africa rallied to 226 tons, as compared with 57 tons and 260 tons. Shipments to Portuguese East Africa have ceased for the present.

SULPHITE SPIRIT AS A SUBSTITUTE FOR BENZINE.—The manufacture of sulphite spirit commenced in Sweden in the year 1909, when one factory was started, two more being erected in 1911. The Industrial Committee of the Commercial Department has recently been investigating the matter, and in a report just handed in strongly advocates that the home manufacture of sulphite spirit should be encouraged, for which purpose a substantial tariff protection is recommended. The three existing factories have an annual production of some 550,000 gallons of 100 per cent. spirit. Further, there are in the country thirty-eight factories for the production of sulphite cellulose, which also can be arranged for the manufacture of spirit. Jointly, with the three existing factories, these are considered capable of producing 5,700,000 gallons of sulphite spirit per annum, which quantity is calculated capable of replacing 3,500,000 gallons of benzine. The Swedish import of benzine has, during the years 1907 to 1914, risen from 1600 to 17,000 tons, but the consumption will, it is thought, rise to 30,000 to 40,000 tons per year. The aggregate production of Swedish sulphite spirit will consequently not suffice entirely to supersede benzine; but it will, in any case, prove a material aid and a good reserve. The cost of production amounts to about 1d. to 7d. per gallon of unmixed sulphite spirit and 12.25d. per gallon for benzol spirit. On this basis, the manufacturing price of benzine will be 16.5d. per gallon. This, however, is considerably higher than the price for imported benzine, which from 1905 to 1914 has ranged between 10d. to 12d. per gallon. A protective duty would therefore be necessary, and the committee propose a duty of 11d. per gallon. As the motor is mainly looked upon in the light of a luxury, the higher price for benzine which the committee's proposal will involve does not appear to have aroused any misgivings.

HUGE IRRIGATION SCHEME IN AUSTRALIA.—Very substantial progress is being made by the Water Commission with its scheme for the supply of the huge Wimmera-Mallee area of some 8000 square miles, which takes its supply from Lake Lonsdale and the Wimmera River. What is known as the Donald main channel is now practically completed as regards that portion which will supply the area known as Sea Lake, consisting of 2500 square miles; and it is anticipated that in January it will be possible to water the numerous branch channels of the Sea Lake system by this means. The connections thus made will also make available the volume of water at present stored up in the new Avon regulator at Batyo Catyo Swamp, which is roughly estimated at 4000 acre-feet. The main eastern channel and East Karkarooc main channel have just been completed, and are now supplying the North-East Borung and East Karkarooc districts. The connections of these channels will most markedly improve the watering of these important districts. Equally good results will follow the completion of the main western channel, which will be in full operation early in January. It will link up the West Karkarooc main channel, and thus enable the whole of the existing branch channels of North-West Borung and West Karkarooc to be rapidly and economically watered by completely saving the great waste that has hitherto taken place through using the Yarriambiac Creek as a carrier. The construction of this channel will appeal to the residents. The channel will give an abundant supply to the Kewell, Wallup, Antwerp, Jeparit, and Rainbow districts, the last of which is situated some 200 miles from the source of supply, and it will do away with the somewhat unsatisfactory pumping supply from Dooen, and instead will provide a gravitation supply. These main channels are part of a complete scheme for a thorough reticulation of the Wimmera area, and by means of various connections the Water Commission will be enabled to utilise with much greater effect the unregulated flows of the Wimmera River. Supplies in storages will be conserved for use during the periods of low-river flow. The Lake Lonsdale storage will be supplemented by storages on Black Swamp and Taylor's Lake, which will give an additional capacity of some 47,000 acre-feet.

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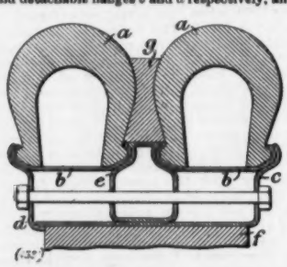
MOTOR ROAD VEHICLES.

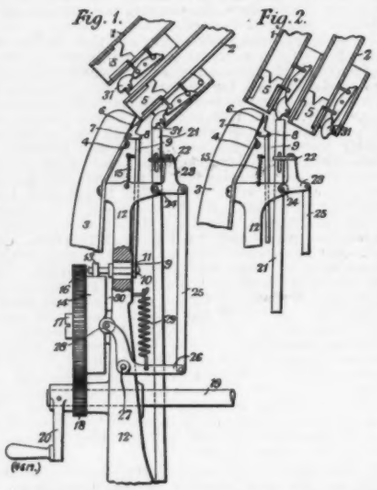
4531/15. S. H. Cope and the Warland Dual Rim Company, Limited, Birmingham. Road-Vehicle Wheels. [1 *Fig.*] March 23, 1915.—This invention relates to road-vehicle wheels fitted with twin pneumatic tyres—that is to say, a pair of tyres which are mounted with the one alongside the other on the rim of the wheel. Ordinarily there is a small space between the two tyres, and it is found that on rough roads stones become lodged within this space and produce a destructive effect upon the tyre surfaces. The invention comprises the employment between the tyres, of a detachable rubber or other filling ring of smaller outside diameter than the tyres, which ring is shaped to fit closely between the tyre surfaces. The tyres (of which the outer covers only are shown) are indicated by *a*. These are mounted on detachable metal rims *b*, which are carried by fixed and detachable flanges *c* and *d* respectively, and a remov-



able central flange *e*, all mounted on the usual felloe *f*. A rubber ring *g*, which is preferably reinforced by canvas or metal, is made of suitable internal diameter to fit over and rest upon the central flange *e* between the two detachable tyre rims *c* and *d*. The outside diameter of the ring *g* is smaller than that of the tyres, so that the periphery of the ring does not come into contact with the road. The sides of the ring are made to a concave section which corresponds to the contours of those parts of the tyre surfaces between which the ring lies when in service. Consequently the thickness of the ring is smaller at the middle than at the inner and outer peripheries. When the tyres are inflated they secure the ring between them and prevent any possibility of accidental detachment. Due to the tight fitting of the ring between the tyres it is impossible for stones to become wedged between the tyres and there produce a destructive effect upon the tyre surface. (*Sealed.*)

PRINTING AND ALLIED MACHINERY.

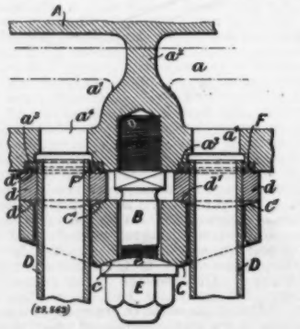
4617/15. Linotype and Machinery, Ltd., London. (*Mergenthaler Setzmaschinen-Fabrik Gesellschaft mit Beschrankter Haftung, Berlin, Germany.*) **Typographical Composing Machines.** [4 *Figs.*] March 24, 1915.—This invention relates to typographical composing machines, especially machines such as those known under the trade-mark "Linotype," in which matrices, stored in magazines, are released from the latter in order of composition, and, after presentation to a casting-mould for the production of casts therefrom, are returned to the magazines. The present invention deals with only such machines as are provided with a plurality of magazines and a single assembler plate, and in which, as is already known, the magazines are adjustable relatively to the assembler plate, or the assembler plate is adjustable relatively to the magazines, so that, at the will of the operator, matrices can be assembled from any of the magazines, according to the font to be employed. In machines of the just-named arrangement, as heretofore constructed, difficulty has been experienced through the track or path followed by the matrices on leaving the magazines and entering the assembler-plate entrance, varying for different magazines brought into use, and the object of the present invention is to provide new or improved means for overcoming or minimising that difficulty, the means comprising a member in pivotal relationship to the assembler-plate entrance, and so arranged and controlled that it will occupy practically the same position relatively to each of the magazines when that magazine is itself in operative relationship to the assembler-plate entrance. Two magazines, 1, 2, are capable of being moved angularly about a pivot so that each of them can be brought into and out of operative relationship to the assembler-plate 3; the just-mentioned pivot is not shown in the drawings, as it is an arrangement which constitutes no part of the present invention, and, moreover, is already well-known in the art. Fig. 1 represents the lower magazine in operative position, and Fig. 2 the upper magazine, and it will be seen by reference to these figures that whereas the angle of inclination of the upper magazine 1 and of the assembler-plate entrance 4 is practically the same when these two organs are in operative relationship, as in Fig. 2, the angle of inclination of the lower magazine 2, when the latter is in operative position, as shown in Fig. 1, differs appreciably from that of the assembler-plate entrance. In order to satisfactorily guide the matrices 5 into the assembler-plate entrance from whichever of the magazines 1, 2, is at the time in operation, there is provided a horizontal guide-bar or switch 6 extending throughout the length of, and pivoted by a rod 7 to, the entrance, so that that bar virtually constitutes a hinged portion of the back plate of that entrance, capable of being turned from the position in which it is shown in Fig. 1 to the position in which it is shown in Fig. 2, and *vice versâ*. The switch 6 has fast to, or integral with, it an arm 8, to which is pivoted the upper end of a rod 9, whose lower end is pivotally connected to a slide 10, free to move vertically up and down in a guide-slot 11 in the fixed frame 12 of the machine, to which frame the assembler-plate 3 is secured in well-known manner. On the front end of the slide 10 is mounted an anti-friction roller 13, constantly held in contact with an edge-cam 14 by a tension-spring 15, attached at its respectively opposite ends to the rod 9 and frame 12. The cam 4 is in rigid connection with a spur-wheel 16 capable of rotating about a fixed stud 17, and meshing with a spur-pinion 18 fast on a shaft 19, by the rotation of which latter is effected the adjustment of the magazines 1, 2 into and out of operative relationship to the assembler-plate entrance 4. The shaft 19 is rotated by means of a crank-handle 20, and one rotation of the cam 14 suffices to move the magazines 1, 2 from one terminal position to the other. The means for transmitting motion from the shaft 19 to the magazines is not shown in the drawings, as it constitutes no part of the present invention. The cam 14 is so shaped that, during the movement of the magazines into and out of their respective operative positions, the switch 6 is turned about its pivot 7 in such manner that when the said operative position is arrived at, the matrix-guiding surface of the switch will have the same, or practically the same, angle of inclination as has the magazine then in such operative position, as shown in Figs. 1 and 2. For



automatically adjusting the escapement reeds 21 to correspond with the altered condition established by the bringing into operative position of the respective magazines 1, 2, the comb-plate 22 in which these reeds are guided at their upper ends, is automatically moved in fore-and-aft direction whenever an operative change of magazine is made. For attaining this result, the comb-plate 22 is secured to a lever or frame 23 capable of rocking about a stationary pivot 24, and having pivoted to it the upper end of a link 25, whose lower end is pivoted to the horizontal arm of a bell-crank lever 26. This lever is free to turn about a pivot 27 fast to the machine frame 12, and has an anti-friction roller 28 pivoted in or to its vertical arm, a tension spring 29 serving to hold the roller constantly in contact with the face-cam 30. The cam 30 is integral with the edge cam 14, or, in other words, it and the said edge cam are different operative surfaces of one and the same body. By the foregoing arrangement, the act of turning the shaft for effecting an operative change of magazine automatically effects simultaneously therewith the adjustment of the switch 6 and of the escapement reeds 21, so that when such operative change is completed, these devices will occupy their proper positions relatively to the magazine 1 or 2 and the escapements 31 with which they are respectively to co-operate. (*Sealed.*)

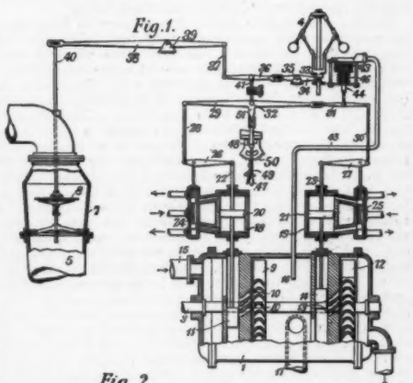
STEAM-ENGINES, BOILERS, EVAPORATORS, &c.

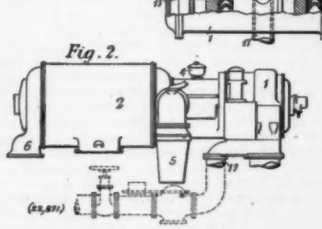
23,569/14. The Vulcan Foundry, Limited, and W. Collingwood, Newton-le-Willows. Tube Joints. [2 *Figs.*] December 4, 1914.—This invention relates to tube joints connecting the ends of superheater or other tubes to a header-box or plate by the aid of bridge-pieces centrally bolted to the header or plate, spherical surfaces being provided between the bridge and the bolt and tube ends to give flexibility and ensure tight joints. According to this invention, the bridge-piece is itself formed with a separate spherical surface for each



tube connection, and for the central bolt, so arranged that any irregularities in the tube connections will not be liable to set up a bending moment and so contribute to the breakage of the bolt or other part. A is the superheater header with saturated and superheated steam chambers *a* and a^1 separated by the web a^2. B is the central bolt, C is the bridge-piece, D, D are the superheater tubes. The central bolt B is formed with a screwed end *b* and a square collar b^1, the end *b* screwing into a tapped hole in the web a^2. The bridge-piece C is formed with the concave spherical surface *c* at its outer side, meeting the convex spherical portion *c* of the nut E on the end of the bolt B. The tubes D (in a superheater construction usually the two ends of a single long superheater tube) are each provided with the collar *d* having a convex spherical surface d^1 which meets the concave spherical surface c^1 at the inner side of the end of the bridge-piece C. To form a tight joint between the tubes D and the header A, the latter is provided with the recessed or rebated channels a^3 at the outer ends of the steam apertures a^4, and in these channels are placed the copper or other comparatively soft metal rings F. An annular wedge d^2 is formed on the face of each of the collars *d*, and this wedge enters the face of a ring F, and presses it firmly against the walls of the channel and the tube. (*Sealed.*)

22,871/14. The Warwick Machinery Company (1906), Limited, London. (*General Electric Company Schenectady, U.S.A.*) **Mixed-Pressure Turbo-Compressors.** [2 *Figs.*] November 21, 1914.—This invention relates to regulating mechanism for mixed-pressure turbine-driven air-compressors of the kind in which both the high and low-pressure valves of the turbine are operated in accordance with the pressure or delivery of the compressor, and are also subjected to a speed-governor to prevent abnormal speeds under emergency conditions. In a mixed-pressure turbine-driven air-compressor, according to this invention, the high and low-pressure valves are simultaneously controlled by a volume-governor associated with the compressor, and a speed-governor and the low-pressure valve is independently controlled by a device responsive to the pressure at an intermediate stage of the turbine. The turbo-compressor set comprises a steam-turbine 1 and a centrifugal air-compressor 2, the rotating elements of both machines being mounted on a common shaft 3, to which is suitably geared a speed-responsive device 4. The compressor has an intake 5 and a delivery-pipe 6. The intake has an enlarged frusto-conical portion 7, in which is located a volume-governor consisting of a disc 8 floating on the inflowing column of air and shifting its position up and down in the intake in accordance with the varying volume of air passing through the intake. The movement of this disc is relied upon to govern the admission of steam to the turbine, and so vary its speed that a constant volume of air will be delivered by the compressor under varying conditions of service. The speed-governor 4 is also placed in control of the turbine to prevent abnormal speed under emergency conditions. The turbine is of the multi-stage type, the drawing indicating this by showing a high-pressure wheel 9 receiving steam from a plurality of nozzles 10 controlled by a valve 11, and a low-pressure wheel 12 receiving steam from a plurality of nozzles 13 controlled by a valve 14. The high-pressure steam is supplied through a pipe 15, while the low-pressure may be the exhaust from the wheel 9 entering the chamber 16, or it may be





supplied to the said chamber from some other source through a pipe 17. The valves 11 and 14 are preferably actuated by hydraulic motors, comprising cylinders 18 and 19, containing pistons 20, 21 connected to the valve-stems 22, 23. Fluid pressure is admitted to the cylinders by pilot-valves 24, 25, which are connected to levers 26, 27, one end of which is pivoted to an extension of the valve-stems 22, 23. The other end of the lever 26 is connected by a link 28 with one end of a floating lever 29, while the corresponding end of the lever 27 is connected by a link 30 with one end of a lever 31, whose other end is articulated to the adjacent end of the floating lever 29. An intermediate point 32 on the floating lever is connected both to the speed-responsive device and to the volume-governor in such a manner that an increase either in the speed of the machine or in the volume of the air entering the compressor will cause a lowering of the floating-lever. As shown, the sliding-collar 33 of the speed-governor is connected by a short lever 34, fulcrummed at 35, to one end of an arm 36, whose other end is connected by a link 37 to a lever 38, fulcrummed at 39, and pivoted at its other end to the stem 40 on which the floating disc 8 is mounted. The arm 36 is pivoted to a short plunger 41, sliding in a stationary guide and pivoted to the floating lever 29 at the point 32. A pressure-responsive device is connected to the lever 31 and actuates it in correspondence with variations in the steam pressure in a stage or chamber of the turbine. The preferable construction is indicated in the drawing, comprising a so-called siphon diaphragm 43, attached to a rod 44, which is pivotally connected to the lever 31. The pipe 45 conveys fluid pressure from the stage or chamber 16 to the diaphragm, so that, upon an increase of pressure in said chamber, the spring 46 will be compressed and the lever 31 will be forced downwardly. The means for positively tilting the floating lever 29 comprises a hand-lever 47, fulcrummed at 48, and having a latch 49 co-operating with a notched quadrant 50. The upper end of the lever is joined to an arm 51 on the floating lever 29 in such a way as not to interfere with the free up-and-down movements of the floating lever, but at the same time enable the attendant to tilt the floating lever one way or the other by manipulating the hand-lever. (*Sealed.*)